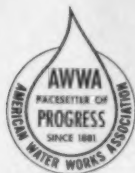


SEPTEMBER 1958



VOL. 50 • NO. 9

Journal

AMERICAN
WATER WORKS
ASSOCIATION

In this issue:

COLORADO RIVER AQUEDUCT

Diemer

REGIONAL WATER RESOURCES PLANNING

Berry, Armstrong, Hazen,
Forrest, Nichols

ARKANSAS-WHITE-RED RIVER BASINS

Krause, Metzler, Short

WATER QUALITY IN KANSAS

Metzler

MISSOURI RIVER BASIN CONTROL

Hatcher, Neel, Erdei, Hartung

COLORADO RIVER RECREATIONAL DEVELOPMENT

Coote

STREAM WATER QUALITY MONITORING

Hartung, Palange, Megregian,
Cleary, Streicher

SINGLE-RUBBER-GASKET JOINTS

Wolfe

STRAY-CURRENT PROBLEMS

Hamilton

STUDIES OF IRON BACTERIA

Wolfe

COMBINED AVAILABLE CHLORINE RESIDUAL

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Journal

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September 1958

Vol. 50 • No. 9

Contents

Colorado River Aqueduct System of Southern California.....	ROBERT B. DIEMER	1121
Reprints Available.....		1126
Ontario Water Resources Act.....	ALBERT E. BERRY	1127
Discussion.....	C. G. RUSSELL ARMSTRONG	1131
Financing and Cost Allocation in Regional Water Supply Systems....	RICHARD HAZEN	1176
Control, Preservation, and Allocation of Texas Water Resources		
Water Problems in Texas.....	T. CARR FORREST JR.	1157
Action on Texas Water Problems.....	MARVIN C. NICHOLS	1160
Water Quality Studies in the Arkansas and Red River Basins.....	KEITH S. KRAUSE	1166
Discussion.....	DWIGHT F. METZLER	1170
Organization of the Arkansas-White-Red Basins Inter-Agency Committee		
JOHN A. SHORT		1175
Improvement of Water Quality in Kansas.....	DWIGHT F. METZLER	1180
Effects of Missouri River Basin Control on Water Quality		
Introduction.....	MELVIN P. HATCHER	1185
Reservoir Influence on Central Missouri River.....	JOE K. NEEL	1188
Water Quality at Omaha, Neb.....	JOSEPH F. ERDEI	1196
Water Quality at St. Louis County.....	HERBERT O. HARTUNG	1198
Recreational Development on the Lower Colorado River.....	ROBERT K. COOTE	1201
Correction—Report of Committee on Water Works Practice.....		1210
Monitoring of Stream Water Quality		
Introduction.....	HERBERT O. HARTUNG	1211
USPHS Program.....	RALPH C. PALANGE & STEPHEN MEGREGIAN	1214
Development of a Robot System.....	EDWARD J. CLEARY	1219
Colorado River Aqueduct System.....	LEE STREICHER	1223
Single-Rubber-Gasket Joints for Cast-Iron Pressure Pipe.....	THOMAS F. WOLFE	1227
Stray-Current Problems Created by Modernizing Direct-Current Traction Lines		
HUGH L. HAMILTON		1231
Cultivation, Morphology, and Classification of the Iron Bacteria.....	RALPH S. WOLFE	1241
Persistence of Combined Available Chlorine Residual in Gary-Hobart Distribution System.....	HERBERT L. PLOWMAN JR. & JOHN M. RADEMACHER	1250
Use of Liquid Alum at Richmond, Va.....	H. E. LORDLEY	1259

Departments

Officers and Directors.....	2 P&R	Service Lines.....	70 P&R
Coming Meetings.....	6 P&R	Section Meetings.....	74 P&R
Percolation & Runoff.....	47 P&R	Condensation.....	84 P&R
Reading Meter.....	66 P&R	New Members.....	104 P&R

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Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 2 Park Ave., New York 16, N.Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918. \$7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—60 cents; single copies to non-members—85 cents. Indexed annually in December; and regularly by *Industrial Arts Index and Engineering Index*. Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

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LIST OF ADVERTISERS

	P&R PAGE		P&R PAGE
Alabama Pipe Co.	115	Inflico Inc.	—
Alco Products, Inc.	—	International Salt Co., Inc.	14
Allis-Chalmers	20	Iowa Valve Co.	7, 67
American Agricultural Chemical Co.	108	Johns-Manville Corp.	—
American Brass Co., The	19	Jones, John Wiley, Co.	63
American Cast Iron Pipe Co.	38	Keasbey & Mattison Co.	99
American Concrete Pressure Pipe Assn.	9	Kennedy Valve Mfg. Co., The	—
American Cyanamid Co., Heavy Chemi- cals Dept.	105	Klett Mfg. Co.	54
American Pipe & Construction Co.	85	Koppers Co., Inc.	—
American Well Works	—	LaMotte Chemical Products Co.	—
Anthracite Equipment Corp.	—	Layne & Bowler, Inc.	42
Armco Drainage & Metal Products, Inc.	71	Leadite Co., The	Cover 4
Atlas Asbestos Co. Ltd.	—	Leopold, F. B., Co.	37
Badger Meter Mfg. Co.	100, 101	Lock Joint Pipe Co.	3
Bailey Meter Co.	57	Ludlow Valve Mfg. Co.	—
Bethlehem Steel Co.	30	M & H Valve & Fittings Co.	75
B-I-F Industries, Inc.	5, 29	Maxim Silencer Co.	97
Buffalo Meter Co.	—	Millipore Filter Corp.	—
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)	5	Mueller Co.	65
Burgess-Manning Co., Penn Instruments Div.	—	National Water Main Cleaning Co.	93
Byron Jackson Pumps, Inc.	—	Neptune Meter Co.	46
Calgon Co.	27, 40	Northern Gravel Co.	66
Carborundum Co., The	—	Omega Machine Co. (Div., B-I-F Indus- tries, Inc.)	29
Carus Chemical Co.	—	Orangeburg Mfg. Co.	43
Cast Iron Pipe Research Assn., The	12, 13	Peerless Pump Div.	28
Celanese Corp. of America	—	Permutit Co.	68, 69
Centriline Corp.	73	Philadelphia Quartz Co.	—
Chain Belt Co.	55	Photovolt Corp.	94
Chapman Valve Mfg. Co.	22, 23	Pittsburgh-Des Moines Steel Co.	—
Chicago Bridge & Iron Co.	—	Pittsburgh Equitable Meter Div. (Rock- well Mfg. Co.)	116
Clow, James B., & Sons	7, 67	Plastics & Coal Chemicals Div.	25
Cochrane Corp.	—	Pollard, Jos. G., Co., Inc.	11
Combination Pump Valve Co.	26	Pratt, Henry, Co.	61
Darley, W. S., & Co.	86	Precision Chemical Pump Corp.	—
Darling Valve & Mfg. Co.	—	Proportioners, Inc. (Div., B-I-F Indus- tries, Inc.)	—
De Laval Steam Turbine Co.	36	Reilly Tar & Chemical Corp.	32
DeZurik Corp.	—	Rensselaer Valve Co.	—
Dicalite Div.	—	Roberts Filter Mfg. Co.	89
Dorr-Oliver Inc.	Cover 3	Rockwell Mfg. Co.	116
Dresser Mfg. Div.	109	Rockwell, W. S., Co.	10
Eddy Valve Co.	7, 67	Rohm & Haas Co.	—
Electro Rust-Proofing Corp.	—	Ronald Press Co.	—
Ellis & Ford Mfg. Co.	—	Ross Valve Mfg. Co.	95
Fairbanks, Morse & Co.	—	Servicised Products Corp.	113
Filtration Equipment	72	Simplex Valve & Meter Co.	33
Ford Motor Box Co., The	41	Smith, A. P., Mfg. Co., The	87
Foster Engineering Co.	70	Smith, S. Morgan, Co.	31
Foxboro Co.	—	Sparling Meter Co.	91
Gamon Meter Div., Worthington Corp.	49	Steel Plate Fabricators Assn.	24
General Chemical Div., Allied Chemical & Dye Corp.	—	Stuart Corp.	86
General Filter Co.	51	Taylor, W. A., & Co.	—
Glenfield & Kennedy, Ltd.	—	Taylor Iron Works	56
Golden-Anderson Valve Specialty Co.	—	Tennessee Corp.	21
Graver Tank & Mfg. Co.	35	Trinity Valley Iron & Steel Co.	—
Graver Water Conditioning Co.	—	U.S. Pipe & Foundry Co.	—
Greenberg's, M., Sons	58	Upson Co.	—
Hagan Chemicals & Controls, Inc.	—	Vulcan Materials Co.	—
Hammond Iron Works	—	Wachs, E. H., Co.	—
Hays Mfg. Co.	39	Walker Process Equipment, Inc.	34
Hersey Mfg. Co.	53	Wallace & Tiernan Inc.	44
Hungerford & Terry, Inc.	106	Well Machinery & Supply Co.	107
Industrial Chemicals, Inc.	—	Wheeler, C. H., Mfg. Co.	59
Industrial Chemical Sales Div., West	—	Wood, R. D., Co.	Cover 2
Virginia Pulp & Paper Co.	45	Woodward Iron Co.	103
Inertol Co., Inc.	111	Worthington Corp.	15, 16, 17, 18

Directory of Professional Services—pp. 76-82 P&R

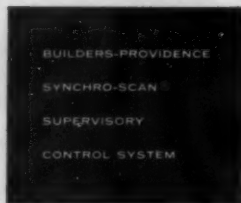


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Coming Meetings

AWWA SECTIONS

Sep. 8-10—Michigan Section, at Pantlind Hotel, Grand Rapids. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, DeWitt Rd., Lansing 4.

Sep. 10-12—New York Section, at Lake Placid Club, Lake Placid. Secretary, Kimball Blanchard, Rm. 1525, 19 W. 50th St., New York 20, N.Y.

Sep. 15-17—Rocky Mountain Section, at Cosmopolitan Hotel, Denver, Colo. Secretary, V. A. Vaseen, Ripple & Howe, 426 Cooper Bldg., Denver, Colo.

Sep. 17-19—Ohio Section, at Statlet Hotel, Cleveland. Secretary, J. H. Bass, Robert F. McGivern & Assocs., 1771—5th Ave., Columbus.

Sep. 17-19—Wisconsin Section, at Hotel Wausau, Wausau. Secretary, Harry Breimeister, Chief Utilities Engr., City Engineer's Office, City Hall, Milwaukee 2.

Sep. 22-24—Kentucky-Tennessee Section, at Peabody Hotel, Memphis, Tenn. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 24-26—North Central Section, at Hotel Duluth, Duluth, Minn. Secretary, L. N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Sep. 28-30—Missouri Section, at Hotel Governor, Jefferson City. Secretary, Warren A. Kramer, State Office Bldg., Jefferson City.

Sep. 28-Oct. 1—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, C. M. Mathews, Mgr., Greenwood Utilities, Box 866, Greenwood, Miss.

Oct. 1-3—Canadian Section, Maritime Branch, at Lord Beaverbrook Hotel, Fredericton, N.B. Secretary, J. D. Kline, Asst. Mgr. & Chief Engr., 162 Lady Hammond Rd., Halifax, N.S.

Oct. 15-17—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 19-22—Florida Section, at Golden Gate Hotel, North Miami Beach. Secretary, John G. Simmons, Plant Supt., West Palm Beach Water Co., Box 1311, West Palm Beach.

(Continued on page 8)

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Coming Meetings*(Continued from page 6)*

Oct. 23-24—West Virginia Section, at Daniel Boone Hotel, Charleston. Secretary, Hugh W. Hetzer, Engr., Design & Construction Dept., Union Carbide Chemicals Co., Box 8361, South Charleston 3.

Oct. 23-25—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 28-31—California Section, at Ambassador Hotel, Los Angeles. Secretary, Roy E. Dodson Jr., Supt. of Production, Water Dept., Balboa Park, San Diego.

Oct. 29-31—Chesapeake Section, at Hotel Dupont, Wilmington, Del. Secretary, Carl J. Lauter, 6955-33rd St., N.W., Washington 15, D.C.

Nov. 5-7—Virginia Section, at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 10-12—North Carolina Section, at O. Henry Hotel, Greensboro. Secretary, D. Y. Brannock, Supt., Water & Sewage Plants, Burlington.

OTHER ORGANIZATIONS

Sep. 15-20—International Congress on Large Dams, Statler Hotel, New York, N.Y. For information, write: US Committee on Large Dams, c/o Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

Sep. 21-25—Prestressed Concrete Institute, Edgewater Beach Hotel, Chicago, Ill.

Oct. 5-8—Annual Conference & Products Exhibit, National Institute of Governmental Purchasing, Hotel Statler-Hilton, Boston, Mass. For information, write: Albert H. Hall, Exec. Vice-Pres., NIGP, 1001 Connecticut Ave., N.W., Washington 6, D.C.

Oct. 5-9—Federation of Sewage & Industrial Wastes Assns., Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 6-8—Northeast Regional Conference, National Assn. of Corrosion Engineers, Hotel Somerset, Boston, Mass.

Oct. 13-17—American Society of Civil Engineers, New York, N.Y.

Oct. 14-17—Pennsylvania Water Works Assn., Atlantic City, N.J.

Oct. 20-24—National Safety Congress & Exposition, National Safety Council, Chicago, Ill.

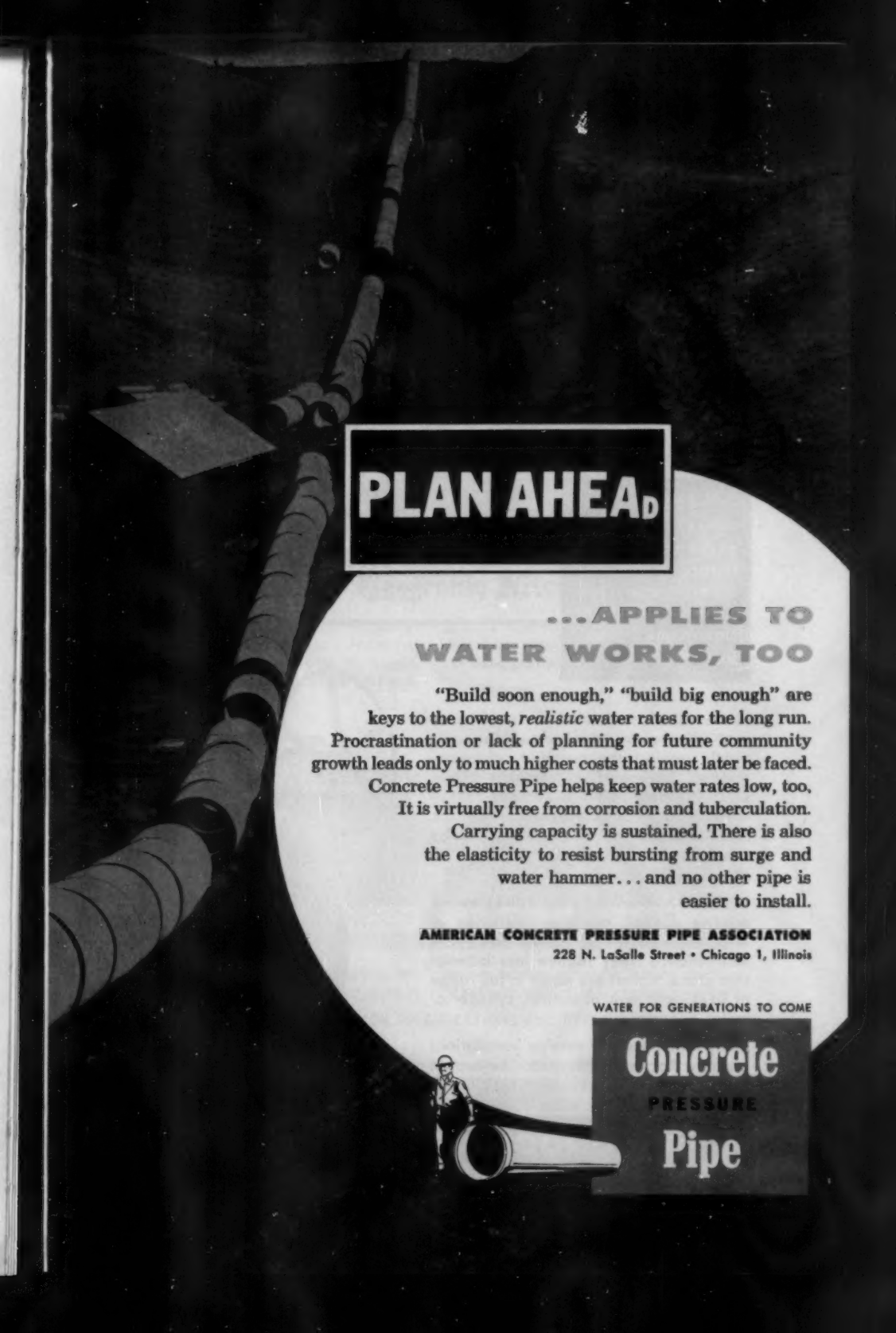
Oct. 27-31—National Metal Exposition & Congress, Public Auditorium, Cleveland, Ohio.

Nov. 5-7—Water Works Management Short Course, sponsored by Illinois Section of AWWA and Univ. of Illinois, Allerton Park, Ill.

Nov. 17-19—National Fire Protection Assn., Pittsburgh, Pa.

Nov. 18-20—National Conference on Standards, American Standards Assn., Hotel Roosevelt, New York, N.Y.

Nov. 30-Dec. 5—American Society of Mechanical Engineers, New York, N.Y.



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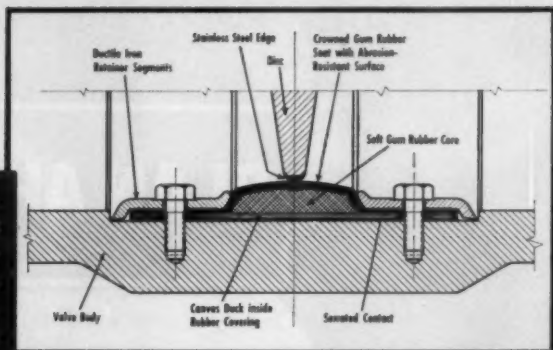
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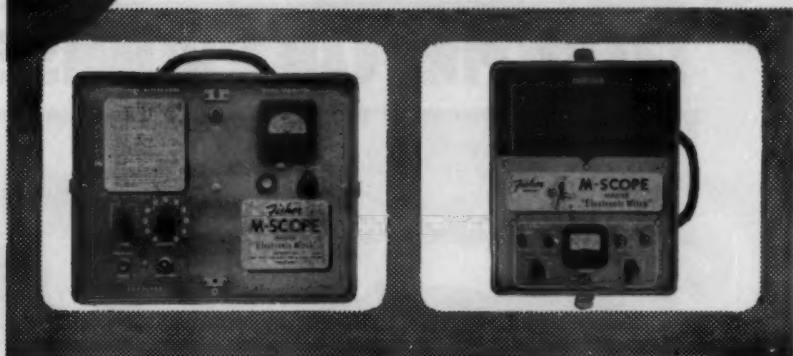


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*Quick
Facts*



LOCATING A LEAK
AT THE VALVE



FINDING A LEAK
UNDER PAVEMENT



ONE MAN
OPERATION



LOCATING
A SERVICE

For greatest convenience and reliability, the M-Scope MASTER is equipped with a

built-in battery tester for instant checking of battery condition in the field or elsewhere.

WRITE TODAY FOR SPECIFICATIONS AND PRICE!

PIPE LINE EQUIPMENT
**JOSEPH G.
POLLARD
CO., INC.**
PIPE LINE EQUIPMENT

Place your next order with **POLLARD**


It's from POLLARD - It's the Best in Pipe Line Equipment -


NEW HYDE PARK • NEW YORK

Branch Offices: 964 Peoples Gas Building, Chicago, Illinois
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ANY PIPE CAN PROMISE...



 **80 YEARS YOUNG!** This 36" Cast Iron Pipe feeder main was installed in 1907. Taken up in 1954 because of relocation project, it was reinstalled in 1956 for a bypass line around new highway interchange.

 Close-up of section of above pipe 1,958 feet of which was cleaned and reused.

MODERNIZED **cast iron**

CAST IRON PIPE PERFORMS!



What other pipe offers you **LONG LIFE + STRENGTH** **+ HIGH FLOW CAPACITY?**

**Don't doubt when you
buy pipe—specify cast
iron and be sure of...**

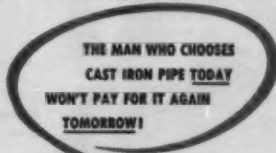
1. **LONG LIFE...**
42 North American cities are still using cast iron water mains laid 100 years and more ago. Hundreds more have passed the 50 year mark.
2. **BEAM STRENGTH...**
Cast iron pipe is inherently tough... stands up under heavy traffic load, soil displacement and disturbance.
3. **HIGH FLOW CAPACITY...**
Cement lined cast iron pipe and fittings will not tuberculate... delivers a full flow for the life of the pipe.
4. **EXTERNAL LOAD RESISTANCE...**
4" Class 150 Pipe withstands a crushing load of 17,900 pounds per foot... nearly 9 tons.
5. **CORROSION RESISTANCE...**
Cast iron pipe effectively resists corrosion... vital factor in its long life and dependability.
6. **TIGHT JOINTS...**
A full range of leak-proof, low cost, easy-to-assemble joints for pipe and fittings are available for all conditions.

You've read and heard thousands of words—all selling pipe.

But make no final choice before you ask this simple question: What pipe offers you not one, not two but *all* the factors that spell long, trouble-free life and dependability.

The answer is... cast iron pipe. Performance made it... and performance keeps it... America's No. 1 Water Carrier.

Its service record *proves* it!



CAST IRON
Cast Iron Pipe Research Association
Thos. F. Walls, Managing Director
Suite 3440, Prudential Plaza, Chicago 1, Ill.

pipe

FOR MODERN WATER WORKS

Using the latest techniques for water-softener regeneration?

An important process in the complete regeneration of zeolite or base-exchange resins in today's water softeners is the production of fully saturated Lixate Brine. This article, number 19 in a series prepared by International Salt Company, describes some of the newest and best techniques for making and distributing this high-quality brine.

"Lixator" Improvements Make Brine Production More Efficient

Widely used throughout industry, Lixators are automatic rock-salt dissolvers developed by International Salt Company. They produce high-quality, fully saturated Lixate Brine—the ideal brine for water-softener regeneration.

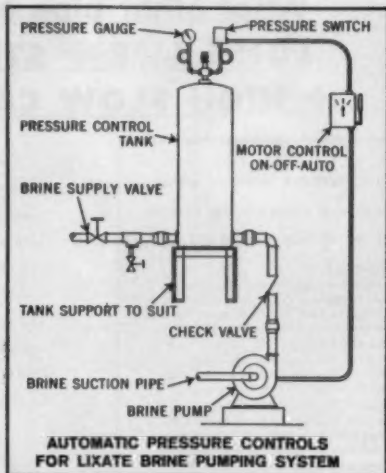
Excellent as this equipment is, International is constantly working to *improve* Lixator designs, and develop special new Lixator attachments. Here are some of these improvements . . .

Low liquid level—a basic design feature that saves money by eliminating the need for deep salt-dissolving tanks. In any Lixator, only the *bottom* portion need be waterproofed to make and store brine. The upper portion is used for dry salt storage—need *not* be made brine-tight.

Electrode controls—an excellent alternative to the standard float controls for regulating the liquid level in a Lixator. Two electrodes, protected in a pipe, are immersed in the Lixator. When the liquid level falls below the lower electrode, a valve opens to admit more water. Flow stops automatically when the level reaches the higher electrode. In this way, the desired brine level is continuously maintained.

Pressure controls (see illustration). International has introduced the technique of starting and stopping Lixate brine pumps by pressure switches. Open a valve anywhere in the brine piping, and line pressure drops slightly. This activates a switch, starting a pump which withdraws brine from the Lixator. Close the valve, and the pump stops. Everything is automatic.

Brine-metering devices. In cooperation with leading meter manufacturers, International has pioneered in the application of highly accurate and specialized meters for brine. Advantages of a metered Lixate system include precise salt measurement, since every gallon of Lixate Brine contains exactly 2.65 lbs. of salt. Also, automatic shut-off



metering devices allow you to preset the amount of brine you want. Flow stops when this amount has been measured out.

In many other ways, brine meters and other Lixator attachments can boost brine-making efficiency. To find out how your plant can benefit from such devices, contact the nearest International Salt Company sales office, or write to us direct.

Sales offices: Atlanta, Ga.; Chicago, Ill.; New Orleans, La.; Baltimore, Md.; Boston, Mass.; Detroit, Mich.; St. Louis, Mo.; Newark, N.J.; Buffalo, N.Y.; New York, N.Y.; Cincinnati, O.; Cleveland, O.; Philadelphia, Pa.; Pittsburgh, Pa.; Memphis, Tenn.; and Richmond, Va.

**INTERNATIONAL
SALT CO., INC.**
SCRANTON 2, PA.



HERE
COME
THE
ANSWERS

JOHN WORTHINGTON
PUBLIC WORKS
REPRESENTATIVE



Worthington's vast reservoir of Public

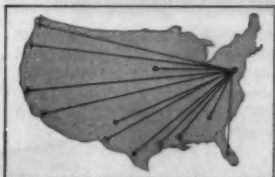
In Public Works there is no adequate substitute for experience. Worthington's experience in this essential field dates back to 1854 when the company's founder installed his first municipal water works pumps at Savannah, Georgia. Others soon followed. A duplex pump was installed at Charlestown, Massachusetts in 1863. Pumping engines were installed in Fort Worth, Texas in 1893. Twelve triple-expan-

sion engines were put in at Philadelphia, Pennsylvania in 1908. Now the list is almost endless. There is hardly a municipality in the United States today that does not have a Worthington pump, compressor, engine or comminutor in service. This vast, cumulative experience and know-how proves invaluable year-in, year-out to communities in search of the very finest in service and equipment.

Key personnel in Worthington's Public Works Department have a combined experience in all phases of water and sewage plants of over 100 years.



Works experience is at your service



NATION-WIDE EXPERIENCE

Public Works representatives from Worthington criss-crossed the nation during 1957 bringing their knowledge to hundreds of municipalities. In so doing, they increased their skills by solving scores of local problems on equipment selection and application.



EXTENSIVE PRODUCT EXPERIENCE

Worthington makes a complete line of specialized equipment for water and sewage works. These are Worthington's basic products and the year they were introduced. Pumps (1840), Compressors (1893), Engines (1896), and Comminutors (1948).



REGIONAL REPRESENTATION

A network of Worthington Offices spans the nation, from New England to California, from Canada to Mexico. Staffed with experts trained in every phase of Public Works, these offices are your assurance of the best possible equipment and the finest possible application.

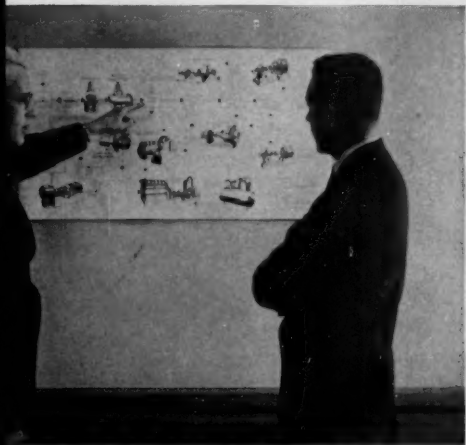
THE 4 BASIC SERVICES of Worthington's Public Works Department



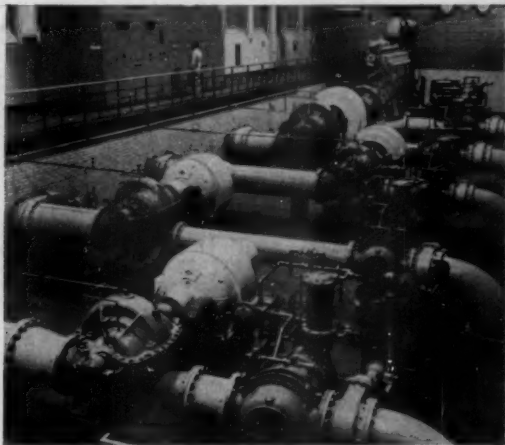
PLANNING Worthington experts will assist your consulting engineers in planning water and sewage plants. This coordinated planning care is why so many Worthington users report such long, outstandingly trouble-free operations.



EQUIPMENT COORDINATION Every municipality is different. No two systems are alike. That's why equipment must be versatile and coordinated. Because Worthington makes so wide a range of equipment, the most complex problems are quickly solved without compromising effectiveness of the system in any way.



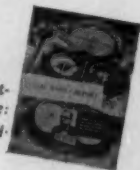
EQUIPMENT SELECTION Because Worthington designs and manufactures a complete line of equipment, a Public Works Representative can make a substantial contribution to the operation of every plant. Using Worthington equipment limits your supply responsibility - makes for greater plant efficiency and integration.



INSTALLATION Public Works specialists are few and far between. Worthington is fortunate in having so many on its staff. They will work with your consulting or contracting engineer in solving installation problems of equipment. It's the soundest way to build dependability in your systems.

WORTHINGTON

For illustrated brochure on Worthington's Public Works Department; or address of your nearest Worthington District Office, write: Worthington Corporation, Section 105-3, Harrison, New Jersey.



Rodney Hunt gates of tough Everdur withstand bleach-plant acid and pulp-mill wastes



Settling tanks of one of the first industrial waste-treatment plants in the paper industry at the Covington, Va., plant of West Virginia Pulp and Paper Co. Everdur was specified for mixing-chamber gates to resist corrosion by bleach-plant acids and pulp-mill wastes.



One of a pair of mixing-chamber gates fabricated of Everdur, each 48" wide by 54" high. The slide is a sheet of Everdur, reinforced by Everdur angles braze-welded in place. Frame and 2" stem also of Everdur.

Resists corrosion. Sewage treatment and waterworks equipment of Everdur* has been in service without replacement for 20 years and longer.

Toughness. Everdur also possesses high strength and resistance to wear and abrasion — so that engineers can use lighter weight wrought material in their designs.

Readily fabricated. Alloys of Everdur are available for hot or cold working, welding, free machining, forging and casting — and can be obtained in plates, sheets, rods, bars, angles, channels, tees, I-beams, wire, tubes, electrical conduit and casting ingots.

Write for Publication E-11, "Everdur Copper-Silicon Alloys for Sewage Treatment and Waterworks Equipment" — or for technical help in selecting the correct material for your job. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ont.

*Reg. U. S. Pat. Off.

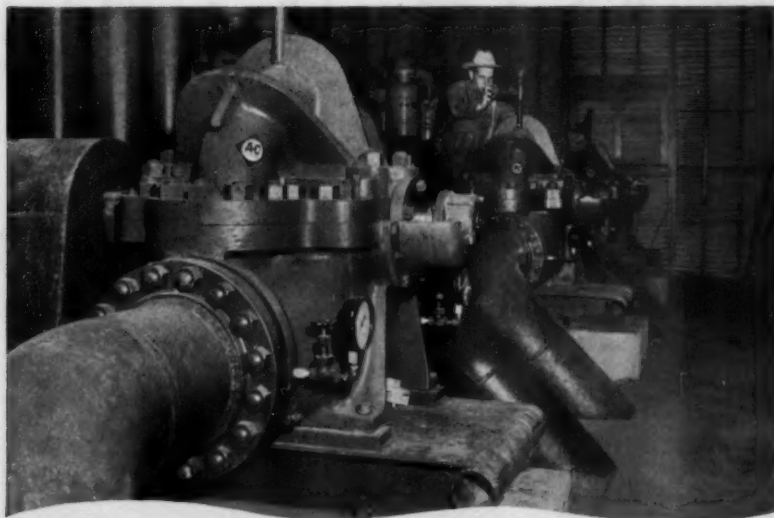
07131

EVERDUR

Anaconda's family of Copper-Silicon Alloys

MADE BY THE AMERICAN BRASS COMPANY

STRONG • WORKABLE • WELDABLE • CORROSION-RESISTANT



Slash municipal pumping costs with nodular iron pump casings

DISTINCT advantages over steel at only a fraction of steel's cost! That's the payoff when Allis-Chalmers pumps with nodular iron casings are applied in waterworks. Corrosion, impact, vibration, oxidation and distortion find better-than-steel resistance in lower-cost nodular iron.

Proof of nodular iron's advantages exists in the Mulvane, Kansas, station of the Augusta-El Dorado Water Association. Here, *without need for costly booster stations*, three Allis-Chalmers pumps in series develop an 870-ft head to provide 5550 gpm over 32 miles of pipelines to two cities and three refineries.

This is only one example of how you can benefit from Allis-Chalmers pump experience. For more information, call your nearby A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS



A-5809

The Superior COAGULANT With The Plus FACTORS—

Excellent taste
and odor control

Increased filter runs

Coagulation over
wide pH ranges

Rapid floc formation

Economy

Turbidity removal

Color removal

Manganese and
Silical removal

Bacteria removal

Ease of Operation



ferri-floc

FERRIC SULFATE

Ferri-Floc gives smoother, more efficient and trouble free operation. Whatever your particular water treatment problem may be, you can depend on Ferri-Floc doing a superior job and doing it efficiently and economically—Ferri-Floc is a free flowing granular salt which can be fed with few modifications through any standard dry feed equipment. It is only mildly hygroscopic, thereby permitting easy handling as well as storage in closed hoppers over long periods of time.

WATER TREATMENT

Efficient coagulation of surface or well waters. Aids taste and odor control—Effective in lime soda-ash softening. Adaptable to treatment of nearly all industrial waters.

SEWAGE TREATMENT

Ferri-Floc coagulates water and wastes over wide pH ranges—It provides efficient operation regardless of rapid variations of raw sewage, and is effective conditioning sludge prior to vacuum filtration or drying on sand beds.

SULFUR-DIOXIDE is effectively used for dechlorination in water treatment and to remove objectionable odors remaining after purification.

COPPER SULFATE will control about 90% of the microorganisms normally encountered in water treatment plants more economically than any other chemical.



FREE BOOKLET

Let us send you without charge, a 38 page booklet that deals specifically with all phases of coagulation—just send us a postal card.



TENNESSEE



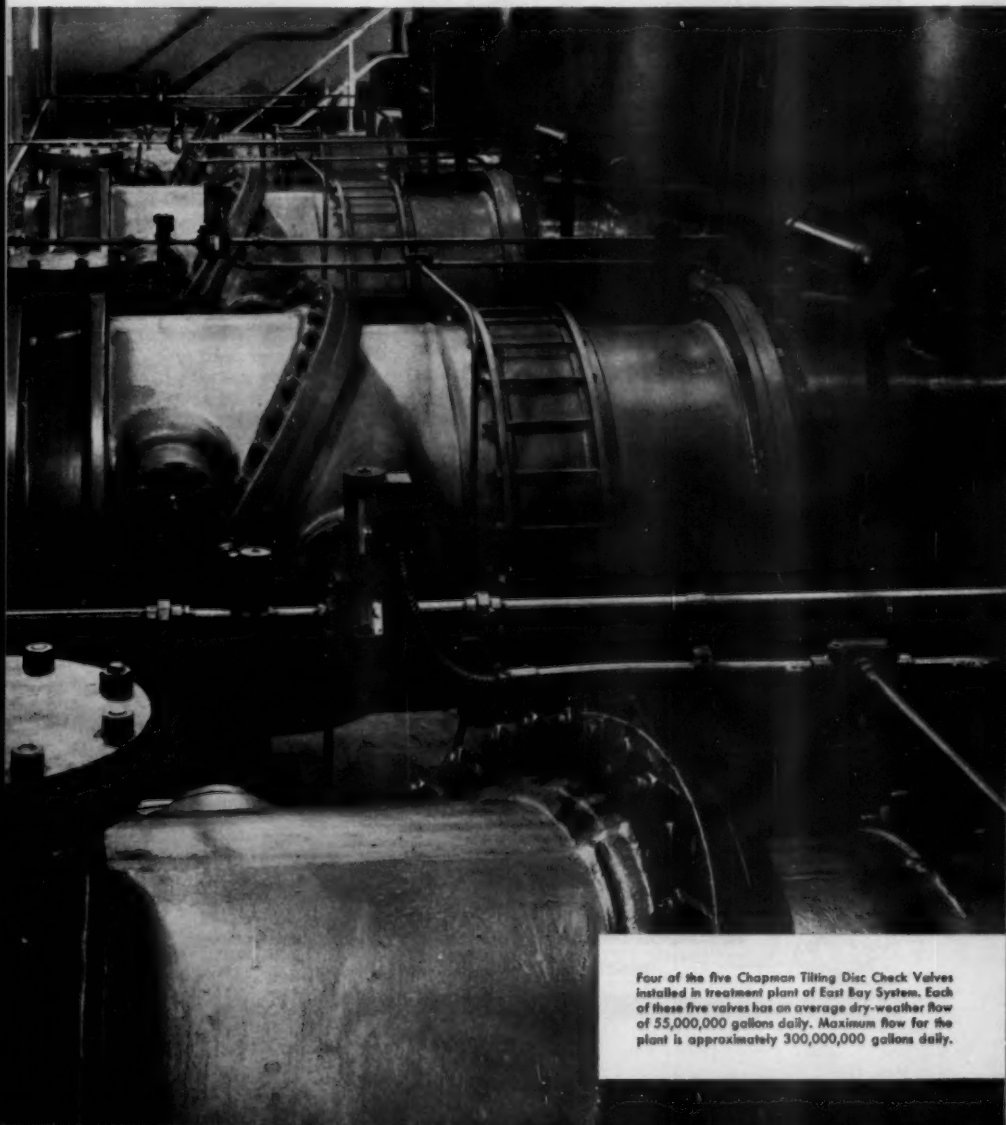
CORPORATION

617-29 Grant Building, Atlanta, Georgia



In Oakland, California,

Main entrance to the East Bay Pumping Station. Engineering and erection of the entire sewage system was handled by the East Bay Municipal Utility District Engineering Staff.



Four of the five Chapman Tilting Disc Check Valves installed in treatment plant of East Bay System. Each of these five valves has an average dry-weather flow of 55,000,000 gallons daily. Maximum flow for the plant is approximately 300,000,000 gallons daily.

*55 million gallons per day flow
quietly through five trouble-free*

CHAPMAN

TILTING DISC

CHECK VALVES

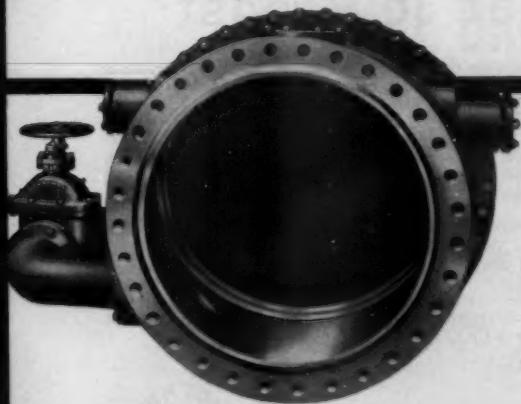
In Oakland, California, the East Bay Sewage Disposal System serves the cities of Oakland, Berkeley, Alameda, Albany, Emeryville and Piedmont. And it serves them well. It has improved health conditions and property values in the large East Bay area.

Representing an investment of \$23,500,000 this system is modern in every respect. Twenty-one miles of reinforced concrete pipe bring sewage from six cities to the central treatment plant. At the treatment plant sewage is immediately chlorinated for odor control then raised 35 feet by five 42-inch pumps to the Grit Chambers from where it can flow by gravity through the rest of the system.

Finely screened sewage is pumped up through five 42-inch Chapman Tilting Disc Check Valves to

prevent any return of the sewage to the Interceptors. Today, the average flow through these five valves is 55,000,000 gallons per day, with some variations. Yet, no matter how much it varies these Chapman Valves handle the flow quietly . . . no flutter, no slamming, no banging, no damage to valve or system. The valves automatically adjust themselves to the volume of the flow.

Chapman Tilting Disc Check Valves were the first with this unique design, engineered to meet standard and unusual conditions of service. Chapman know-how is one of the many reasons why its valves and control equipment are selected for installations of all kinds. Write, and one of our engineers will tell you more of the ways and whys.



Left: — Chapman Tilting Disc Check Valve with 6" bypass connection similar to the Chapman Check Valves installed in the East Bay Sewage Disposal System.

Why not send for our free Catalog No. 30-B showing and giving full information on all Chapman Tilting Disc Check Valves.

The CHAPMAN Valve Manufacturing Company

INDIAN ORCHARD, MASSACHUSETTS

For over 75 years, Chapman has devoted its entire facilities to the valves of today and tomorrow. Chapman has the engineers, metallurgists, experience and manufacturing facilities to design, develop, build and test the valve equipment you need no matter how tough the requirements.



STEEL PIPE | delivers water at low cost

There are two big reasons why steel pipe delivers water at low cost: 1. Steel pipe is economical to install. 2. Steel pipe is economical to maintain.

Long lengths of comparatively lightweight steel pipe are easy to ship and handle. With long lengths, fewer field joints are required, thus reducing labor costs, installation time, and possibilities of leaks. Steel pipe also requires a minimum of excavation and backfill. Because of its strength and flexibility, steel pipe can often be assembled and joined in long lengths above the trench and then lowered into position.

Savings possible with steel pipe continue throughout the long life of the line in the form of low maintenance costs and no leakage losses. Strong yet ductile steel pipe withstands the damaging actions of unstable foundations, freezing, water hammer, floods, and washouts.

So when you want a pipeline that costs you less to install and will cost you less for years to come, you're wise to specify STEEL PIPE.

"WHEREVER WATER FLOWS—STEEL PIPES IT BEST"

**STEEL PLATE FABRICATORS
ASSOCIATION**

105 WEST MADISON ST., CHICAGO 2, ILL.





**NOW
IS NOT
THE TIME
FOR PIPE DREAMING**

You can't afford to speculate with corrosion control!

Today you are tightening up on business operations. Risks are out. For pipeline protection you can't afford to get away from time-tested corrosion control methods. Protective Coating Materials by Plastics and Coal Chemicals Division give you constant protection—superlative continuity, impermeability, bond, body strength, stability, and chemical inertness. Made from highest quality coal-tar pitch—the shield that has proved best!

Proved and improved for three generations, these Pipeline Primers, Enamels, and Auxiliary Protective Pipeline Felts, form a maximum barrier against corrosive elements.

A staff of Field Service experts are at your call to offer you technical assistance that saves you maintenance time and costs.

Always tell your applicator to use Protective Coating Materials produced by Plastics & Coal Chemicals Division. Write for full information.

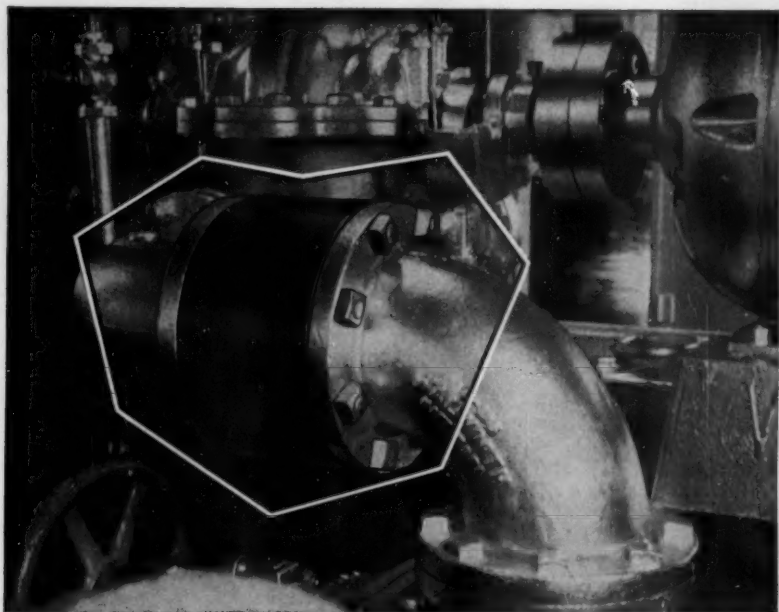
PLASTICS AND COAL CHEMICALS DIVISION

Formerly part of the Barrett Division

40 Rector Street, New York 6, N. Y.

In Canada: Allied Chemical Canada Ltd., 1450 City Centre Blvd. St., Montreal

**Allied
Chemical**



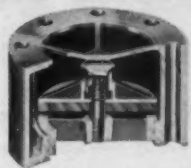
ELIMINATE BACK-DROP, SURGE AND HAMMER

When CPV silent, non-slam check valves are installed on the discharge of centrifugal pumps, the whole system is protected against waste and harmful surges. The need for expensive air cushions and other anti-hammer devices is eliminated.

Spring-actuated, CPV check valves close automatically as soon as flow ceases. Back travel, which can be so damaging, is not required for closing.

Users report CPV valves easy to install and require no maintenance. Unique design includes bearing guides on both sides of disc and a full flow area in excess of pipe area. The valve operates in any position.

For complete specifications and prices write Combination Pump Valve Company, 853 Preston Street, Philadelphia 4, Pa.



STYLE "G"—2 to 10"



STYLE "GB"—6" and up



SILENT
NON-SLAM

CHECK VALVES

CALGON®



CONTROLS



TUBERCULATION

Tuberculation cuts down flow capacities . . . raises pumping power requirements . . . steps up costs. Calgon provides the simple, economical way to control this costly corrosion.

Calgon treatment is particularly effective after mechanical main cleaning because of its fast film-forming ability. Protection for freshly scoured metal surfaces is quickly

built up and easily maintained. Calgon treatment is inexpensive—a few ppm control tuberculation and other corrosion problems as well.

A letter or phone call will bring you more information on the many ways in which Calgon can help. Or, an experienced Calgon engineer will be glad to make detailed recommendations on your specific problem.

CALGON COMPANY



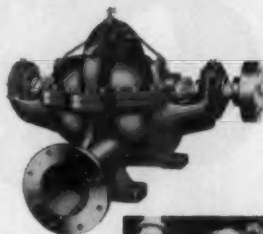
DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
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design / application

"Field tested" for thousands, perhaps millions, of years, the simplicity of design of this sea shell has proved its practicability as dependable housing. In its field, the design of the Peerless Type A horizontal split-case pump is quite as remarkable. The split at the center line allows easy maintenance without disturbing the piping. The rotating element lifts out as a unit for inspection or repair. Mechanically and hydraulically, the quality and operation of this pump is unsurpassed — *it is the type of pump you can apply with absolute confidence to general purpose pumping duties in the broadest sense.* An added advantage: the Type A pump line is the broadest offered by any manufacturer.

REQUEST BULLETIN NO. B-1300.



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FOOD MACHINERY AND CHEMICAL CORPORATION

Peerless Pump Division

Plants: LOS ANGELES 31, CALIFORNIA and INDIANAPOLIS 8, INDIANA

Offices: New York; Cleveland; Chicago; St. Louis; San Francisco; Atlanta; Plainview; Lubbock; Phoenix; Albuquerque; Los Angeles; Fresno. Distributors in Principal Cities. Consult your telephone directory.

FEEDING SODA ASH?

DRY? LIQUID?
BY WEIGHT?
BY VOLUME?



You can depend upon Omega for the most complete line of SODA ASH FEEDERS. Omega is backed by a wealth of practical experience and equipment knowledge to help you to select the right feeder for your requirements.

In addition, Omega will supply aux-

iliary equipment and instrumentation: totalizers, master control panels, remote controls, proportional pacing systems, alarms, batch counters, and other related units.

Send for Bulletins you want . . . see table below. **Omega Machine Co., 365 Harris Ave., Providence 1, R. I.**

	CLASS OF FEEDER	ACCURACY	RANGES		BULLETIN NUMBER
			MIN.	MAX.	
GRAVIMETRIC (WEIGHING) DRY FEEDERS Required for Precision Automation and Instrumentation	MODEL 30-1 LOSS-IN-WEIGHT	$\pm 1\frac{1}{2}\%$ by weight	$\frac{1}{4}$ to 50 lbs./hr.	7.5 to 750 lbs./hr.	30-H12A
	MODEL 30-8 BELT	$\pm 1\%$ by weight	2 to 200 lbs./hr.	25 to 2,500 lbs./hr.	35-G5A
	MODEL 37-20 BELT	$\pm 1\%$ by weight	6 to 600 lbs./hr.	100 to 10,000 lbs./hr.	35-M62
VOLUMETRIC DRY FEEDERS For Limited Automation But No Instrumentation	MODEL 50A DISC	$\pm 1\%$ by volume 3% by weight	.25 to 5 lbs./hr.	2 to 40 lbs./hr.	50-A57A
	MODEL 20 UNIVERSAL	$\pm 1\%$ by volume 5% by weight	.5 to 20 lbs./hr.	5 to 200 lbs./hr.	20-P2
	MODEL 45 ROTOLOCK	$\pm 1\%$ by volume 5% by weight	1.5 to 150 lbs./hr.	90 to 5,000 lbs./hr.	45-HB
VOLUMETRIC SOLUTION OR SLURRY FEEDER	MODEL 85 ROTODIP	$\pm 1\%$ by volume	5 to 200 gal./hr.	18 to 1,000 gal./hr.	65-H12B



OMEGA MACHINE CO.

DIVISION OF

B-I-F INDUSTRIES



METERS
FEEDERS
CONTROLS

5 cities report on . . .

The long service life of tar-enameled steel pipe



ST. LOUIS—60-in. ID tar-enameled pipe, some 30, some 20 years old, still on the job and reported to have given "uniformly satisfactory service."

BALTIMORE—54-in. ID tar-enameled main installed in 1915. Inspections disclose no leaks or loss of flow capacity. Giving good service today after 42 years.

MINNEAPOLIS—Portion of 19.5 mi. 48-in. ID tar-enameled steel main crosses Mississippi River, cradled under bridge, completely exposed to the rigorous climate. Through nine years with a temperature range of 132 degrees, the pipe has functioned "perfectly."

SYRACUSE—54-in. ID steel pipe installed underwater in 1893 (asphalt lined) and 1938 (tar-enameled). "Inspections indicate that both are in excellent condition today."

TAMAQUA, PA.—30-in. ID tar-enameled steel pipe used continuously since 1932. Despite highly corrosive coal-bearing soils, undermining, and soil subsidence, there has been no damage to the pipe, and flow capacity is "as good as ever."

No other large-diameter water pipe can approach tar-enameled steel pipe in its strength to withstand high pressure from within and destructive forces from without; its leak-proof joints; its ability to span washouts; its resistance to corrosion; and its maintenance of high flow capacity. And, remember, every length of steel pipe is hydrostatically tested after fabrication as required

by AWWA specifications, usually to twice the required working pressure!

Bethlehem Steel is one of the nation's leading manufacturers of tar-enameled steel pipe.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL





Eight 24" SMS-Rotovalves are used for pump check service at the Secondary Pumping Station of the U. S. Air Force's Arnold Engineering Development Center in Tullahoma, Tenn.* Installed on 25,000 GPM pumping units, each hydraulically-operated Rotovalve has independent timing control for opening and closing, and a by-pass fast closure device for shut down in the event of power failure. Four more 24" Rotovalves perform similar service at the Primary Pumping Station.

CLOSE CONTROL OF TIMING MAKES SMS-ROTOVALVES CHOICE AT TULLAHOMA

When laying out the cooling water facilities at Tullahoma, Robert and Company Associates of Atlanta, Consulting Engineers under contract with the Tullahoma District, Corps of Engineers, U. S. Army, selected SMS-Rotovalves for pump check service. Close, positive control of valve opening and closing time that minimizes water hammer as pumps are cut in and out of the system made Rotovalves the first choice. Their rugged design and record for low maintenance cost were also important for this severe service.

SMS-Rotovalves' full-line opening offers no more resistance than straight pipe of the same diameter, means less head loss and lower pumping costs. Maximum initial shut-off, with retarded area reduction at the closing end of the stroke, controls water hammer. Opening and closing can be as fast as one second, or as slow as needed. Closure is drop tight, and monel-to-monel seats are self-purging.

You can obtain full information on SMS-Rotovalves, Ball Valves or Butterfly Valves by contacting our nearest representative. Or, write to S. Morgan Smith Co., York, Penna.

*Under construction by the Corps of Engineers, U. S. Army.

S. MORGAN SMITH



AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED, TORONTO

Rotovalves • Ball Valves • R-S Butterfly Valves • Free-Discharge Valves • Liquid Heaters • Pumps • Hydraulic Turbines & Accessories

NEW REILLY 230 X-1 PRIMER

- ① Reilly announces a Plasticized Coal Tar Enamel Primer, designed for maximum bond development.
- ② Quick-drying (20 minutes \pm has been reported).
- ③ Non-sagging and non-curtaining.
- ④ Great coverage (750 to 1400 square feet per gal.).
- ⑤ Stability of bond—no degradation of bond with time and temperature exposure.
- ⑥ Derived wholly from coal tar materials, thus fully conforms to A. W. W. A. and governmental agency standards.
- ⑦ Gives 100% reliability factor to coating process when properly applied with plasticized coal tar enamel.



ARMED
Protective Coatings

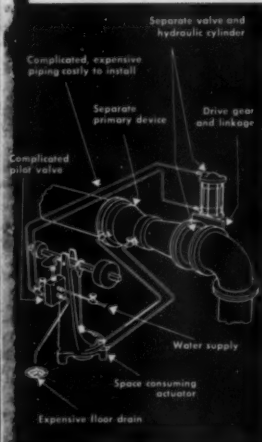
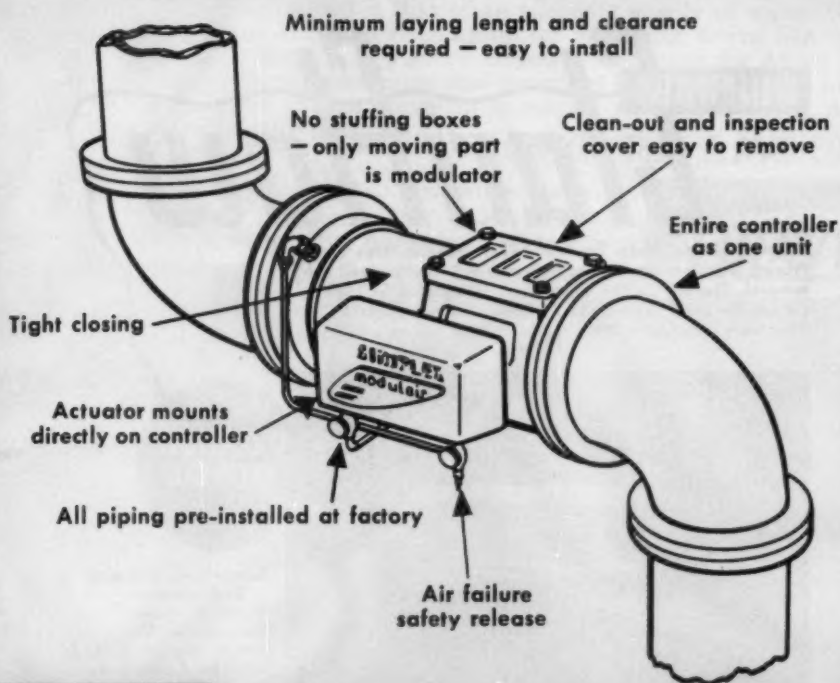
More to come. Reilly 230 X-1 Primer is the first of a series made possible by a significant break-through in applied coal tar surface chemistry. HS X-1 for Reilly Hot Service Enamel and QD X-1 for Reilly Intermediate Enamel will soon be available.

REILLY TAR & CHEMICAL CORPORATION

1615 MERCHANTS BANK BUILDING

11 So. Meridian Street

INDIANAPOLIS 4, INDIANA



COMPARE and see how new Modulair® Flow Controller makes this design obsolete

best of all . . .

Simplex Modulair saves you money three ways

During 6 years of extensive use, the Modulair Rate of Flow Controller has proved time and time again that it can save money three ways:

1. Its unit construction makes it your best buy on a first cost basis.
2. You save installation time and money. Modulair is as easy to install as a piece of pipe.
3. Maintenance is practically nil, because of Modulair's exceptionally simple design.

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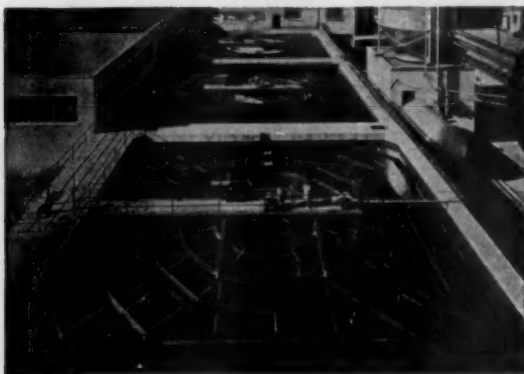
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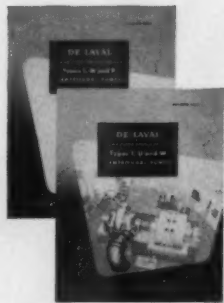
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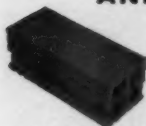
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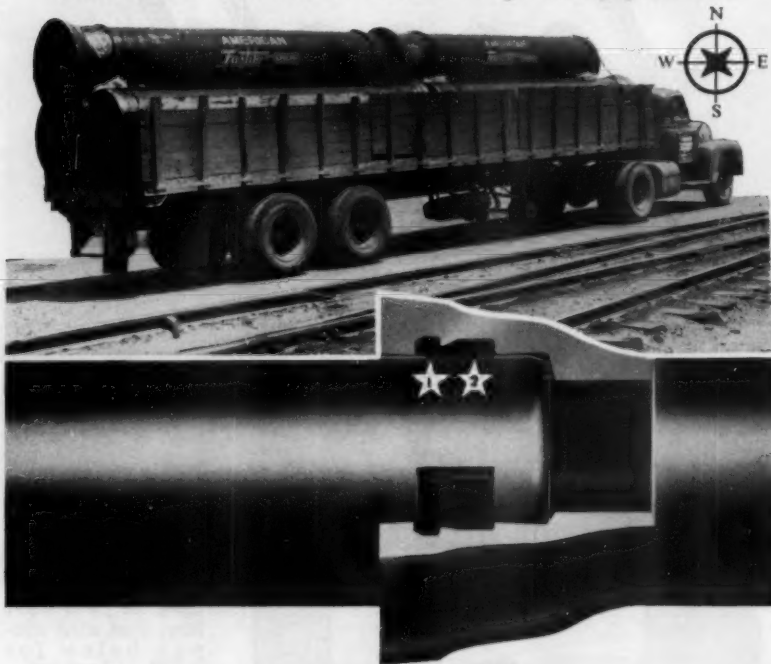
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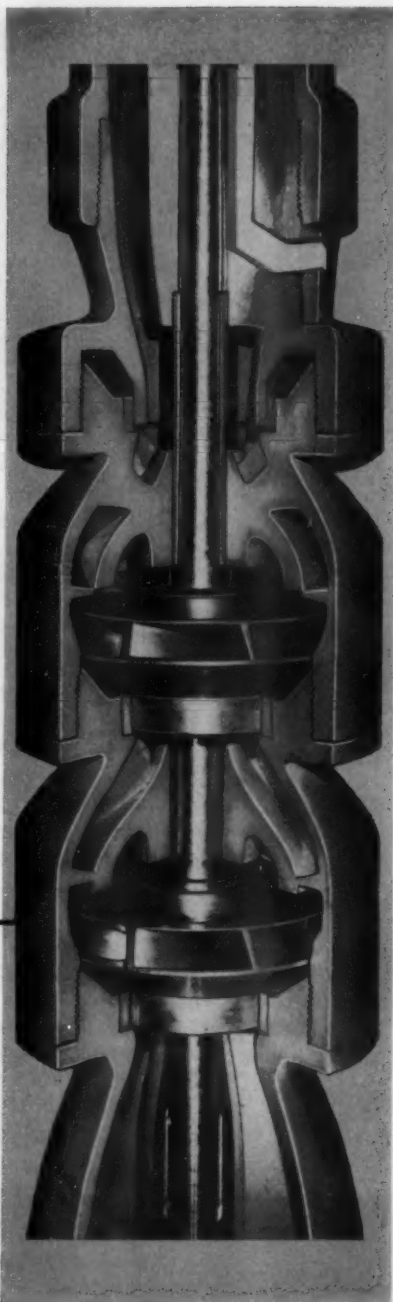
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AMERICAN WATER WORKS ASSOCIATION

VOL. 50 • SEPTEMBER 1958 • NO. 9

Colorado River Aqueduct System of Southern California

Robert B. Diemer

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by Robert B. Diemer, Gen. Mgr. & Chief Engr., Metropolitan Water District of Southern California, Los Angeles, Calif.

ON Apr. 15, 1958, at a special ceremony in Pasadena, Calif., Louis R. Howson of Chicago, President of the American Society of Civil Engineers, presented a plaque to the Metropolitan Water District of Southern California (Fig. 1), giving recognition to the Colorado River Aqueduct as one of the "Seven Civil Engineering Wonders of the US." The Metropolitan Water District organization is proud to have its aqueduct given this engineering recognition, and is conscious of its great responsibility in keeping a semiarid region provided with adequate supplies of water.

Southern California is a section where more people have come to live and work, in a region farther removed from adequate water supplies, than has been true of any other part of the earth. More than 50 years ago, Southern California began to change from a

grazing and agricultural area to a horticultural territory with growing urban centers. In order to meet this change it became increasingly evident that water supplies would have to be imported from distant sources. Today, in Southern California water is being brought from outside sources through two aqueducts extending 250 and 360 mi to the north and east. The city of Los Angeles completed the Owens River Aqueduct in 1913, with a capacity to import about 320,000 acre-ft of water per year. The longest, and largest, domestic water supply line thus far planned, constructed, and placed successfully into operation is the Colorado River Aqueduct of The Metropolitan Water District of Southern California. It was completed in its initial development in 1941, using \$180,000,000 from the proceeds of a \$220,000,000 bond issue authorized

by the voters of the district in 1931. It will have an ultimate capacity of 1,212,000 acre-ft annually.

Colorado River Aqueduct

The Metropolitan Water District is a political subdivision of the state of California, organized in 1928 under a general law known as "The Metropolitan Water District Act." The district, when organized, included eleven cities within its boundaries, with a total area of 624 sq mi, a population of 1,600,000,

River to Lake Mathews, its terminal reservoir. The terminal reservoir has a capacity of 107,000 acre-ft

Most features of the aqueduct were constructed on the basis of an ultimate capacity of 1,605 cfs required to deliver 1,212,000 acre-ft annually from the Colorado River. Some features, because of economic reasons and estimated future water requirements, were constructed to partial capacity, limiting the original capacity of the aqueduct to about 425,000 acre-ft per year. The



Fig. 1. Colorado River Aqueduct

This map shows the complete Colorado River Aqueduct system. The main aqueduct extends 242 mi from the Colorado River to Lake Mathews.

and an assessed valuation of 2.2 billion dollars. In September 1931, a bond issue of \$220,000,000 was approved by the voters, by a ratio of nearly 5 to 1, to furnish funds to build an aqueduct from the Colorado River to Southern California. Actual construction was started in December 1932, and the aqueduct was put into operation in June 1941. The aqueduct extends 242 mi across a desert waste of mountains and deep canyons from the Colorado

main aqueduct system initially had: [1] five pumping stations, each with capacity to lift 600 cfs of water 1,617 ft over the mountains; [2] 92 mi of 16-ft diameter concrete-lined tunnels; [3] 63 mi of concrete-lined canals; [4] 55 mi of 16-ft diameter covered concrete conduits; [5] 29 mi of inverted siphons; and [6] 22 mi of inverted siphons with 805 cfs capacity. The remainder of the siphons, tunnels, canals, and the cover conduit were built

for a full capacity of 1,605 cfs. A distribution system of large-diameter pipelines totaling more than 350 mi has been built to deliver the water from the aqueduct into San Diego County, and from Lake Mathews, the terminal reservoir, into the other four counties, San Bernardino, Riverside, Orange, and Los Angeles, which comprise the district. The aqueduct system also includes nine reservoirs with a total usable capacity of 154,000 acre-ft, and 237 mi of high-voltage power lines from Hoover Dam to the aqueduct pumping plants.

The Parker Diversionary Dam, located 150 mi downstream from Hoover Dam, was built by the US Bureau of Reclamation with funds furnished by the district. The concrete arch structure is 320 ft high, and raises the water level 70 ft above the level of the stream. Due to the depth of stream deposits, it was necessary to carry the dam foundation 250 ft below the stream level. The reservoir formed above the dam has a capacity of 717,000 acre-ft and serves as a desilting basin which removes practically all silt from the supposedly muddy Colorado River.

Metropolitan District Operation

In 1930, the Metropolitan Water District entered into a contract with the federal government under which it agreed to guarantee the payment for 36 per cent of the firm power generated by the Hoover Dam. In the early days of aqueduct construction and operation, only a small part of this power was required, and it was necessary for the district to pay more than \$4,000,000 for Hoover Dam power which it did not use. In order to eliminate this expense, since water demands were low during the first years of

aqueduct operation, the district entered into contracts with the Los Angeles Department of Water and Power, Southern California Edison Co., and the California Electric Power Co. for the sale of its unused power. During the past 3 years, however, it has been necessary for the district to purchase energy from these companies to pump water to meet increasing water demands.

Since the Colorado River Aqueduct was put into operation, the cost for operation and for maintenance of unsoftened water has varied from \$10 to \$12 per acre-ft. This includes replacement charges, but excludes bond redemption and interest. The organization necessary to operate, maintain, and patrol the aqueduct system has about 300 employees, including administrative personnel. From 1941 to date the district has delivered water to its member agencies in wholesale quantities at rates varying from \$8 to \$12 for natural Colorado River water, and \$15-\$22 for softened and filtered water which is only available to the west of the softening and filtration plant. This plant is at La Verne, which is 25 mi east of Los Angeles on the district's 750-cfs capacity upper feeder.

With the completion of the aqueduct in its first development and the beginning of operation in June 1941, the district was ready to supply the water needs of Southern California. Thirteen years had passed since the formation of the district in 1928. The district then included only 624 sq mi. Adjacent areas had little interest in obtaining additional water supplies from the Colorado River. These areas had normal rainfall in those years and the underground basins seemed to have an ample supply for all time.

During the first fiscal year of operation, the District delivered only 16,000 acre-ft of Colorado River water to Southern California. This is equivalent to a 1-pump flow for less than 2 months. In this first year, however, the aqueduct, even though operated at low efficiency for its member cities, supplied water in 1942 for United States forces training for the African campaign. In the latest fiscal year of 1956-57, the district delivered 543,000 acre-ft, nearly 35 times as much as in 1941-42.

During the first 14 years of operation, from 1941 to 1955, water sales required only the pumping of 1,800,000 acre-ft of water from the aqueduct. In this period, with continuous operation of the three available pumps at the five pumping stations, it would have been possible to deliver a total of more than 6,000,000 acre-ft of water.

During the past 10 years Southern California has had an amazing increase in population and industrial growth. Rainfall, however, has been subnormal for 10 of the past 13 years. This population increase and the extended drought resulted in mass annexation to the district, beginning in 1946. The district now has a total area exceeding 3,000 sq mi, including 83 incorporated cities, a population of 6,500,000, and an assessed valuation of more than eleven billion dollars. The terms of annexation for the new areas to the district require the annexed areas to pay, over a period of 30 years, all of the money they would have paid in taxes had they been a part of the district since 1928, plus interest at 4 per cent. This gave the new areas opportunity to buy into the district on the same basis as the original cities which formed it.

No unusual operating problems have been experienced on the aqueduct. Tunnels, conduits, canals, and siphons have required very little maintenance. Algae problems on the canal system through the desert were eliminated by application of copper sulfate. On the terminal reservoir and the distribution reservoirs, the practice of spot treatment with copper sulfate to control scattered growths of algae was practiced throughout the years and a general treatment was seldom required over the full surface of the reservoirs.

On the distribution system all classes of conduits have been used. After almost 20 years all steel pipe is in excellent condition. Interior coatings of coal-tar enamel are in good condition. The district was one of the first large water-supply agencies to use spun-mortar interior coating for the protection of steel pipe. Where connections have been made into the pipelines, the steel shows no evidence of corrosion. Precast concrete pipe has rendered excellent service. Several miles of 28-in. diameter cast-iron pipe has also been in service without any interruptions. The principal operating difficulty on the aqueduct system has been to meet the water demands that developed so rapidly due to the drought and the increasing population.

Underground Basins

Southern California has several large underground basins which, together with water imported by the Owens Valley Aqueduct and local surface supplies, provide a safe annual yield of approximately 1,150,000 acre-ft. During the early years of the operation of the aqueduct, the cities and the private water companies preferred to pump from the underground basins at tem-

porarily lower costs. As a result, the overdraft of these basins now amounts to about 300,000 acre-ft annually. Sea water intrusion in two of the principal basins is gradually advancing at a rate of 700-1,000 ft annually.

These underground basins are the most valuable class of water storehouse in case of disaster or drought. Southern California has finally realized that something must be done to save this valuable storage system. Since 1949 purchases of imported Colorado River water for spreading and recharging these basins have exceeded 600,000 acre-ft. Money for the purchase of water for spreading in Orange County is obtained by the Orange County Water District from a replenishment assessment of \$3.90 per acre-ft on all water pumped from the basins, and an *ad valorem* tax rate of eight cents per \$100 of assessed valuation. These funds are sufficient to purchase about 85,000 acre-ft per year.

Expansion Plans

In order to obtain funds for the expansion program, the district requested the legislature to amend the Metropolitan Water District Act. This amendment permitted a proposition to be submitted to the voters on Jun. 5, 1956, authorizing the district to issue short-term notes to help finance an expansion program to bring the Colorado River Aqueduct up to its full planned-delivery capacity. The proposition was approved by the voters by a ratio of 11 to 1. The notes are to be repaid, with their interest, out of money coming to the district as annexation fees already pledged by annexed areas. In 1956 there was approximately \$170,000,000 in such annexation fees payable to the district within the next 30 years.

To meet the great and growing need for Colorado River water a major expansion program calling for more than \$200,000,000 was started in 1952, to be completed in 1960. This means that when the aqueduct has been brought to full capacity it will represent a capital investment of about \$500,000,000. Most of the construction work was done with 1930 and 1940 dollars; if the entire aqueduct were built today, it would cost more than a billion dollars. A large part of the new expansion work already has been completed. To date, \$100,000,000 has been spent, and \$40,000,000 is under contract; contracts soon to be let exceed \$60,000,000.

Three additional pumps and a second 10-ft diameter delivery line have been installed at each of the pumping plants. Contracts have been awarded for the installation of the three remaining pumping units to bring each plant to its full capacity of nine 200-cfs pumps. One of these pumps is a spare, or standby, unit.

Construction is under way to install 22 mi of 13- and 13½-ft diameter aqueduct siphons. Plans are being prepared for the enlargement of Lake Mathews from 107,000 to about 180,000 acre-ft, and for increasing the filtering capacity of the district's softening and filtration plant from 200 to 400 mgd. A second aqueduct to supply more Colorado River water to San Diego County was started during the year to meet the rapidly increasing water demands due to the unprecedented increase in population. The first aqueduct was built by the federal government in 1946, before San Diego became a part of the Metropolitan Water District. The second barrel of the first aqueduct was completed in 1954; combined capacity of the two barrels is

200 cfs. The second aqueduct now under construction will deliver 250 cfs to San Diego. Water demands for the past 3 years have required continuous operation of the first aqueduct. The carrying capacity of the first aqueduct decreased 20 per cent during the summer of the first year of operation, due to organic slime deposits on the interior of the 72-in. diameter concrete pipe. The original capacity of the San Diego line has been restored and maintained by frequent chlorination.

When the aqueduct expansion program is completed in 1960, the district will be ready to meet the estimated water requirements of Southern California until the year 1975. It is not too soon to start planning for the next imported supply, which may be water from the state's proposed Feather River Project. All sections of the United States should provide water when it is needed, and not delay progress until it is too late. Southern California almost waited too long.

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Ontario Water Resources Act

Albert E. Berry

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by Albert E. Berry, Gen. Mgr. & Chief Engr., Ontario Water Resources Com., Toronto, Ont.

NEW water legislation has been adopted by the province of Ontario. The purpose of this legislation is an adequate supply of water to all Ontario communities, under the most favorable possible conditions of financing and administration. Construction of sewage works, as a means of protecting the water resources of the province, is a part of this overall plan. This legislation, unique in Canada, and probably in most countries, resulted from a number of factors which developed over a period of time.

Ontario is one of the ten provinces of Canada. It has a population of more than 5,500,000, of a total of 17,000,000, and an area of 412,582 sq mi of a total of 3,845,974 sq mi for all Canada. Much of Ontario is sparsely settled, and this creates problems where community projects are involved. Southern Ontario has the highest concentration of population, and has been a focal point for industrial growth. Opportunities for growth of both the industries and population of Ontario are tremendous. Expansion has been taking place in recent years at an unprecedented rate.

It is recognized that such growth cannot be sustained unless adequate water supplies are available. The importance of the Great Lakes to southern Ontario is evident. Large communities and industries have been

attracted to these bodies of water. Now, as the inland areas of the province increase in population and development, the problem of adequate water supplies takes on new significance.

Inland communities in a large part of southern Ontario have serious water problems, including quantity, quality, and pollution control. Costs for the development and transportation of water have increased sharply and high interest rates have added to them. Where water must be piped long distances, it is an advantage to deal with this problem on a regional basis, rather than for a number of municipalities to act separately.

By 1955, the need for water, and also sewage works, was sufficiently urgent to require action at the provincial level. This was especially true in southern Ontario, which experienced a major postwar expansion, and which gave every promise of continuing to expand if there were no serious restrictions to growth. Water was recognized as a primary need.

Water Resources Act

The government of the province recognized the need for action. A water resources and supply committee was appointed in 1955 to investigate and to advise on steps which should be taken. The committee consisted of five members, under the chairmanship of

A. M. Snider. The report of the committee was followed by legislation, in April 1956, which created a Water Resources Commission of five members, also under the chairmanship of A. M. Snider. Appropriate authority to organize and to make remedial measures was passed by the Ontario legislature. This bill was considerably enlarged, in April 1957, under the title, "The Ontario Water Resources Commission Act, 1957." Some further amendments were made in the act in 1958. The Water Resources Commission Act provided the administrative means for the commission to proceed with its program.

The authority of the Water Resources Commission is set out in Sec. 16 of the act:

Notwithstanding any other act, it is the function of the commission, and it has power:

(a) to control and regulate the collection, production, treatment, storage, transmission, distribution, and use of water for public purposes, and to make orders with respect thereto;

(b) to construct, acquire, provide, operate, and maintain water works, and to develop and make available supplies of water to municipalities and persons;

(c) to construct, acquire, provide, operate, and maintain sewage works, and to receive, treat, and dispose of sewage delivered by municipalities and persons;

(d) to make agreements with . . . one or more municipalities or persons with respect to a supply of water or the reception, treatment, and disposal of sewage;

(e) to conduct research programs and to prepare statistics for its purposes; and

(f) to perform such other functions . . . as may be assigned to it. . . .

The act may be divided into two parts: one deals with construction of water and sewage projects by the commission, the other with supervision of

all water and sewage utilities in the province.

The program for construction projects is a distinct departure from past practice. The object is to help municipalities meet their requirements for these projects. The commission offers financial advantages, as well as expert technical assistance in the planning, construction, and operation of the utilities. This relieves the municipality of the necessity for borrowing or issuing bonds for these purposes.

The supervisory part of the act has resulted in the transfer to the Water Resources Commission of the power to supervise water and sewage utilities built and maintained by municipalities or persons. This power was not only transferred to the commission from the Ontario Department of Health, but it was also considerably expanded, to permit more effective control. This was particularly true in regard to stream pollution.

The organization of the commission has been designed to facilitate its various activities. The commission of five members decides on all matters of policy. Administration comes under a general manager acting through six divisions or branches: administration, laboratories and research, construction, plant operation, sanitary engineering, and water resources. The staff at present consists of more than 100 employees and it is increasing steadily. A new, modern laboratory is under construction to serve not only the commission's needs, but also those of all the municipalities in the province.

Construction Project Procedure

The procedure of the commission in its construction program has the following features:

1. Any municipality is free to decide whether it wishes to do the work itself or place it under the authority of the Water Resources Commission. If the latter course is adopted, an agreement is made between the municipality and the commission under which the commission undertakes to design, build, finance, and operate the project. A standard form of agreement is used, subject to minor alterations to meet local conditions. The agreement on a project may involve one or more municipalities or industries.

2. The projects undertaken by the commission are usually confined to supply, purification, and delivery of water through feeder mains to the contracting party's distribution system, or to the trunk sewers, treatment works, and sewer outfalls. It is only in the case of small communities that the commission undertakes the construction of local water distribution mains or sewage collection systems. In those instances, it is advantageous to have all the work done under one contract and one management.

3. When an agreement is concluded the commission draws up the necessary plans and specifications. The policy of the commission has been to appoint consulting engineers to oversee the construction and also to maintain field supervision. The consulting engineers work for the commission rather than for the municipality. The construction engineer must also maintain resident engineers and a field staff to supervise construction. The commission maintains its own construction branch to insure that the work is carried out to its satisfaction.

4. Contracts are awarded by the commission. Payments are made to the contractor, and to others, by the commission.

5. The agreement between the municipality and the commission is based on the commission's assuming responsibility for the operation and maintenance of the utility during the lifetime of the indebtedness assumed for its construction. When the utility is put into service, it comes under the direction of the operating branch of the commission. The operating personnel for the project are hired and paid by the commission. Where the utility is small and does not require the services of a full-time staff arrangements are made to hire some local public employees, or others, on a part-time basis.

6. There is a provision in the agreement whereby, at the request of either the municipality or the commission, the utility is returned to the municipality at the termination of the indebtedness. Extensions or enlargements of the utility may be made by the commission at the request of the municipality, however. In this way the debt-retirement period may be extended almost indefinitely.

7. An important part of the program is the means of cooperation between the commission and the municipalities served. Each municipality is asked to appoint a local advisory committee to work with the commission in dealing with all aspects of the program. In this way there is local direction for such matters as appointment of employees, wages paid, and many other features of administration.

8. The commission offers to a municipality extensive services in the operation of the works. There is the closest coordination in all technical matters and the advice of the local engineering staff is combined with the specialized training of the commission's personnel. In small municipalities where new utilities are being installed

and where there is no local experience on such matters, the commission advises on rate structures, collection procedures, bookkeeping, records, and many other details.

Financing Construction and Operation

The financial arrangements for projects constructed and operated by the Water Resources Commission are important. High interest rates recently have added to the burden of municipalities in financing many undertakings. Under the plan offered by the commission the municipality does not have to issue or sell debentures or bonds. The money is obtained by the commission, which is backed by the credit of the province. This debt is repaid over a long period, 30 years in most instances, and the interest rate is the actual cost of the money borrowed by the commission. This rate is usually lower than it is possible for the municipality to obtain on its own. The commission can obtain funds by the sale of its own bonds, which are guaranteed by the province, or it can borrow directly, as it has to date, from the provincial treasurer.

In addition to the lower interest rate, there are a number of other advantages in this method of financing. One is the flexibility of the agreement. The municipality makes no payment to the commission until the utility is put into operation. The debenture period may be made to suit local needs. Capital payments may be deferred at the outset up to 5 years. The interest rate will vary each year, and if the prevailing interest rate is lowered, the municipality makes a further saving.

In Ontario, financial obligations of all municipalities come under the supervision of the Ontario Municipal

Board. In these projects the board determines whether the obligation to be undertaken comes within the ability of the municipality to carry.

Where a number of municipalities, or other parties, are concerned with a single project, the agreement provides for allocation to each of the capital debt for which they will be responsible to the commission. The cost of the water delivered, or other services rendered, is based on this, and on the actual cost of operation. A good illustration of this division of obligation is seen in the water project for Essex County. (*See the discussion following this article.*)

The basis of all financial agreements with municipalities is that they shall pay to the commission the actual cost of the debt and the services rendered. The latter do not include the supervisory services of the commission, but only services of those operators actually engaged on the project. No money grants are involved. The contracting municipality will pay, in quarterly installments, to the commission the estimated amount of capital and operating charges, as well as a reserve fund for contingencies, repairs, and replacements. At the end of the year an adjustment is made with the actual costs. These financial procedures relieve the municipality of all the details involved in borrowing money for capital construction.

Sanitary Supervision

The other part of the Water Resources Commission's program involves sanitary supervision over water and sewage utilities, to prevent pollution of streams, ground water, and other sources. This is similar to supervision normally exercised elsewhere by a provincial or state health department. All plans for water and sewage

utility installations or extensions require the approval of the commission before construction is undertaken. The commission is given wide powers to protect the safety of water supplies.

The act places considerable emphasis on the control of stream pollution. It is fortunate that sewage and waste disposal was combined with water supply under the commission's authority. If water resources are to be made available for the maximum use and public benefit, then pollution control must be exercised rigidly. The commission has full control over the protection of all water supplies against pollution. Heavy penalties are provided for infringement of its antipollution regulations. These regulations are not confined to factors which may only affect public health, but are widened to include anything which may impair the quality of water. A good deal of the activity of the commission at present is devoted to sewage and waste disposal and the abatement of stream pollution.

Summary

The program of the commission is in its early stages. The Water Resources Commission Act has been in effect only since April 1957, but it is gratifying to note the number of projects which have been undertaken. To date, agreements have been made with 25 municipalities, involving 21 separate

projects. The estimated expenditure for these projects is more than \$13,000,000. Three water projects have been completed and are now in operation. In addition to agreements already made, many others are pending covering both small and large utilities. Water supplies will be piped substantial distances, and advantageous sources of supply will be developed. Southwestern Ontario is fortunate in being situated adjacent to the Great Lakes. This source of supply will be given careful study, but so also will ground water and inland streams and lakes. Transporting water over large distances is, of course, more economical when a large number of consumers is to be supplied.

The plan which has been adopted in Ontario is designed to facilitate the development of water supplies and sewage disposal for all municipalities, whether they are located inland or on large bodies of water. This plan is one more development in an overall program aiming at close cooperation between the province and the municipalities. To what extent this program will develop in the future remains to be seen, but the results to date have been gratifying. Water has been made available to communities where there is a need for it, and sewage treatment for pollution abatement has been provided.

Discussion

C. G. Russell Armstrong

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The province of Ontario extends 1,000 mi from east to west, and 1,050 mi from north to south. Southern Ontario has the same latitude as north-

ern California, and the city of Windsor, Ont., is actually south of Detroit, Mich. Ontario has a total area of 412,582 sq mi, and contains about 250,000 lakes.

In spite of the large number of lakes in the province, in Essex County, Ont.

(Fig. 1), there are no inland lakes. There is, however, water on three sides: Lake St. Clair on the north, the Detroit River on part of the north and on the west, and Lake Erie on the south. Rainfall is not overabundant in

in the water supply and sewage disposal field over the next 30 years. The St. Lawrence Seaway will undoubtedly help increase the growth of Ontario in industrial potential as well as population.

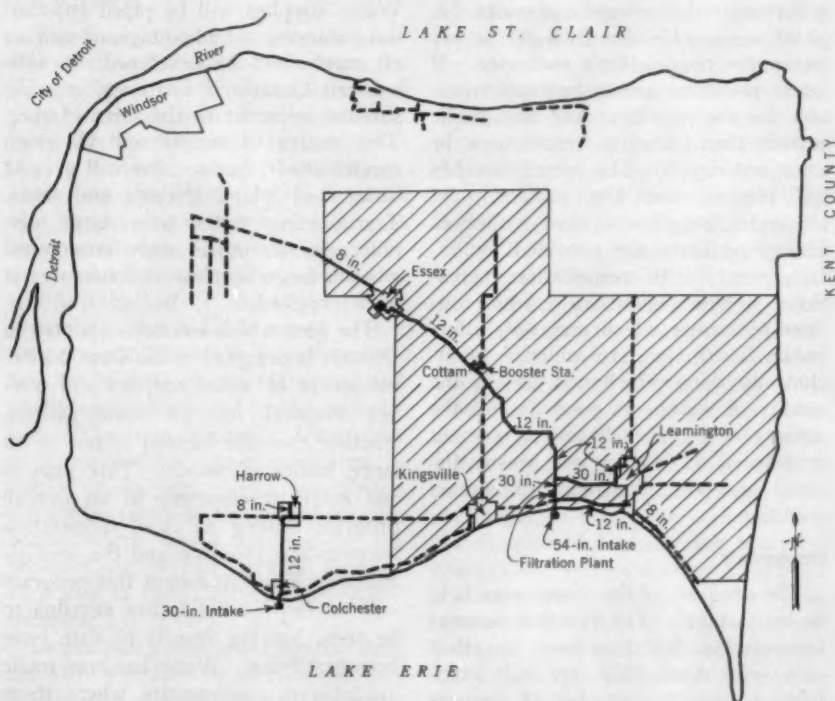


Fig. 1. Essex County, Ontario

This map shows the areas and municipalities discussed in this article and some of the water facilities proposed under the Ontario Water Resources Act. The shaded portion indicates the area of the Essex County Integrated Water Scheme. Essex County is about 33 mi from east to west and 25 mi from north to south.

Essex County, and some years there is a scarcity. Many areas are now resorting to irrigation, to improve crop production.

The Ontario Water Resources Commission will, it is anticipated, be responsible for considerable development

Integrated Water Scheme

The Essex County Integrated Water Scheme is the first major water system set up under the Water Resources Commission Act. This is the first plan of its kind in Ontario in which the problems and requirements of several

communities and industries have been considered as a whole, and an attempt has been made to integrate all of these groups into a single scheme and satisfy the reasonable demands of each. This scheme may be an indication of the possibilities of this kind of coordinated system elsewhere in Ontario. There have, of course, been problems, but generally speaking a fair degree of success in bringing communities together and arriving at a satisfactory agreement has been achieved.

The scheme will serve, principally, the towns of Leamington and Essex, and the rural areas constituting the townships (subdivisions of the county) of Mersea, Maidstone, Gosfield North, and Gosfield South (see Fig. 1). There is a large industrial water demand in this area from the canning industry. In Leamington is the H. J. Heinz Co. of Canada, the largest company of its kind in the British Empire; in Essex is another large canner, the Stokely-Van Camp Co.

West of the area of the Integrated Water Scheme in Essex County, a similar but smaller system has been set up to serve the area around the towns of Colchester and Harrow. It was originally intended that the municipalities surrounding Harrow should participate in a scheme which was principally concerned with supplying water to the town of Harrow. As a result of a popular vote, however, this area decided not to enter the scheme at the present stage. The geographical arrangement is such that, if necessary at a later date, these townships and municipalities could be incorporated into the facilities being provided.

Water Requirements

The towns in the area of the Essex County Integrated Water Scheme, particularly the town of Essex, have been

very short of water. Water was required for both consumption and fire protection. The Heinz Co. required immense quantities, in relation to the population of the district, during a short period of the year. This complicated the installation of the pumping plant and the sizes of the various pipelines. Consumers in the Integrated Water Scheme area are divided into two classes: those who require water for fire protection and for consumption and those who require it for fire protection only. Many people in the area have private wells, which provide adequate drinking water but do not have sufficient pressure for fire-fighting purposes.

The requests of all users have been met, as far as possible. Each individual requiring a connection to the main was permitted to apply for it. Any individual not requiring a connection has not been forced to participate. All of the area required water for fire protection, however, and a minimum charge was made for water on that basis. The basis for the charges is the quantity of water used in any single year within a particular area.

Table 1 shows the estimated consumption and cost of water in the area of the Integrated Water Scheme. These figures apply whether the water is for fire protection and consumption or only for fire protection.

Financial Arrangements

The geographical location of the various districts in the Essex County Integrated Water Scheme enabled the Water Resources Commission to set up two payment areas, an eastern area and a western area. Each participant within these areas was to pay for the common items for construction in direct relation to his annual consumption

of water. The cost of the remaining items of construction, which were particular to the area in which they were located, would be shared among participants in that area, again in relation to their individual annual consumption within the area. Table 1 shows common and direct costs to the municipalities and townships and to the Heinz Co.

The funds supplied by the commission are to be repaid by the individual participants over a period of about 35 years. Per capita annual charges will decrease as population and consumption increase, as the annual repayment sum will be the same each year.

water mains, but an agreement between the commission, the participating municipality, and the contractor for that portion of the work arranged for the contractor to collect the applicable portion of the contract figure from the municipality.

The annual payment to the commission will include the items:

1. Interest on the whole principal at the prevailing interest rate for each applicable calendar year

2. A sinking fund of 2 per cent of the principal, which will be sufficient to build up a fund equal to the whole principal before the term of the contract expires

TABLE 1
Costs, Charges, and Consumption in the Integrated Water Scheme Area

Consumer	Capital Costs—\$			Annual Charges—\$			Estimated Annual Consumption mil gal*	Estimated Cost† \$/1,000 gal*
	Common	Direct	Total	Common	Direct	Total		
Leamington	565,504	361,127	926,631	61,197	26,832	88,029	436	0.20
Essex	215,206	507,754	722,960	23,289	38,408	61,697	166	0.37
Mereau Township	59,692	336,595	396,287	6,460	25,194	31,654	46	0.69
Malden Township	12,567	148,042	160,609	1,360	11,127	12,487	10	1.25
Gosfield South Township	15,708	10,078	25,786	1,699	773	2,472	12	0.21
Gosfield North Township	28,275	67,256	95,531	3,060	5,087	8,147	22	0.37
H. J. Heinz Co.	673,893	430,833	1,104,726	72,927	32,011	104,938	520	0.20

* Imperial gallons; multiply by 1.2 to convert to US gallons.

† Approximate.

The financial cooperation which was achieved between the municipalities and the canning companies was gratifying. The possibilities of setting up similar schemes in the future will be enhanced if the initial approach is made with a view to giving every consideration to all participants and satisfying their requests whenever possible.

The parts of the scheme which were particularly applicable to individual townships, and are referred to in Canada as local improvements, comprised such items as house connections and fire hydrants. Local improvements were included in the contract for the

3. A reserve fund of $1\frac{1}{2}$ per cent of the principal for depreciation and future expansion

4. The applicable portion of the whole annual operating costs, including maintenance, power, chemicals, and other costs.

Design Features

A combination of engineering and economic problems arose from the Essex water scheme because of the wide variation between average- and peak-demand conditions created by the canning industries. Most of the scheme area is a holiday area on the shores

of Lake Erie (Fig. 1), and the canning industry peak-demand period, unfortunately, coincided with the period of peak holiday population. This increased the requirements of the district to considerably more than was normal for the winter months. The design of the filtration plant was based on an initial 8-mgd peak; normal winter demand is only about 2.5–3 mgd. The storage reservoirs are rather small from an engineering standpoint, but the rest of the plant has been designed adequately, and with considerable flexibility, to enable it to cope with wide variations in demand. The plant has been set up with automatic controls to enable it to run with very little attention to operation. It is felt that this will enable the plant to handle system demand almost automatically, rather than depending on men to operate various items of equipment by hand control. In this respect, the plant is extremely modern in its design. It is hoped that this plant will be reviewed with interest, and perhaps establish a trend in treatment plant design in Canada.

A major economic consideration was the pipeline to the town of Essex, which was about 14 mi long. The facilities of the town for financing such a line were limited. The result was a compromise between the engineering and the economic aspects of the prob-

lem. Although it was considered preferable to have a 16-in. line into the town, a 12-in. line was decided upon. If the town increases in population it will be able to afford an extension or an increase in the size of pipe at a later date. The town of Essex will receive water at low pressure and repump it to an elevated storage tank from an existing ground storage reservoir by its own pumping facilities. The town's present water supply is well water; it has high sulfur content, and is undesirable both as a potable water supply and as an industrial supply. At present, the town is almost at a standstill in its growth due to defects in quality and quantity of water.

The scheme has been designed so that it can readily be extended. Many of the rural areas which are serviced will undoubtedly expand and become more heavily populated, particularly along and adjacent to the roads which are served by the mains. The town of Kingsville is very near the filtration plant (Fig. 1), and although it does not wish to enter the scheme at this stage, at some later date it may find it more economical to join rather than to extend its own water plant facilities. As Kingsville will undoubtedly require considerable quantities of water, the filtration plant layout is designed for considerable future extension.

Financing and Cost Allocation in Regional Water Supply Systems

—Richard Hazen—

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by Richard Hazen, Partner, Hazen & Sawyer, Engrs., New York, N.Y.

REGIONAL water supply projects and systems serving two or more communities are born of necessity. They are formed when inadequate local supplies make it necessary to bring water from other areas, or to build major supply works. If communities join forces, the initial capital cost can be shared and the burden on each participant is lessened. Such cooperative ventures are not as numerous as might be expected. Political autonomy and the desire to "go it alone," are strong forces in the United States. Perhaps more important is the fact that neighboring towns do not exhaust their local supplies simultaneously. One community will need immediate action and be unable to wait for its neighbors. The action taken may be inadequate or temporary, but, for the time being at least, the town will no longer be interested in regional arrangements. Proposals for joint action have also often failed because of lack of agreement on how the works should be financed and the costs allocated.

The material for this article has been assembled in connection with studies for a supply system to bring water from the Yadkin River to a number of North Carolina cities. This project will be described later in this article. The Yadkin River project would furnish water wholesale to the several

cities, and each city would continue to distribute retail water. This article is limited to this type of development, and does not discuss the more common situation in which one large water company or water district retails water to many municipalities. Another related problem, sharing water costs between a city and the suburbs that it services, is also not discussed.

Financing and cost allocation of joint water supplies are illustrated by describing five water supply projects: [1] Metropolitan Water District of Massachusetts; [2] joint supply serving Salem and Beverly, Mass.; [3] North Jersey District water supply; [4] joint supply from Lake Huron serving Saginaw and Midland, Mich.; [5] Metropolitan Water District of Southern California.

Regional Projects

A brief sketch of the history and physical features of the projects will help to give a clear picture of the problems involved.

1. *Metropolitan Water District of Massachusetts.* The Metropolitan Water District (Fig. 1) was established by the Massachusetts legislature in 1895 to serve Boston and suburban communities within 10 mi of the city. The district took over the Boston city supply works and distribution reser-

voirs and completed the construction of the Wachusett and Sudbury reservoirs and other appurtenances, at a total cost of about \$47,000,000. The system had a safe yield of 165 mgd. In 1926 the commission began work on the supply from the Swift and Ware Rivers, including the 386-bil gal Quabbin Reservoir and a 300-mgd aqueduct to the Wachusett Reservoir. The new works, costing about \$70,000,000, increased the safe yield of the system to 330 mgd. They went into operation in 1941.

setts legislature in 1913. It was formed to provide works for the diversion of Ipswich River water into existing reservoirs to form a joint water supply for the two cities. A filter plant was added in 1935 and the Putnamville Reservoir was built in 1955. Approximately \$4,000,000 has been spent on the joint facilities, which now furnish, on the average, 7.5 mgd. From the filter plant, 1 mi north of Beverly, separately owned high-lift pumping stations deliver water to each

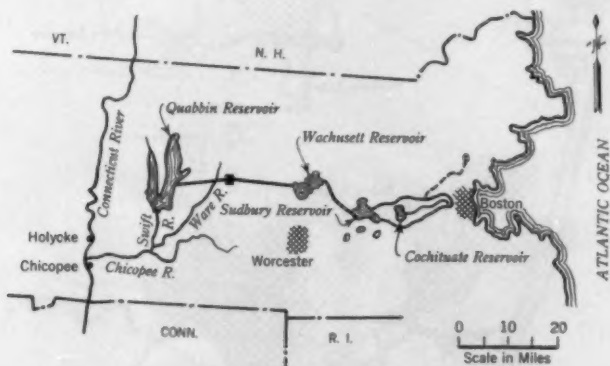


Fig. 1. Metropolitan Water District of Massachusetts

This project was established in 1895. It now supplies more than 200 mgd to a population of more than 1,600,000.

The district originally served eighteen communities with a population of less than 900,000. It now serves 30 communities with a population of more than 1,600,000. Water consumption has increased from 100 mgd in 1900 to 202 mgd in 1956. Annual assessments total approximately \$4,000,000, of which one-quarter is for operation and maintenance and three-quarters for fixed charges.

2. *Salem-Beverly Joint Supply.* The Salem and Beverly water system (Fig. 2) was authorized by the Massachu-

city. Operation and maintenance of the board's facilities cost about \$100,000 a year. Much of the debt has been paid off and fixed charges are low.

3. *North Jersey District water supply.* The North Jersey District water supply (Fig. 3) was authorized by the New Jersey legislature in 1915. A commission was granted jurisdiction over twelve counties in the northern part of the state and was authorized to investigate water supply developments for municipalities within those

counties and, upon petition, to construct water facilities for communities within the district. The Wanaque River project was started in 1920 and went into operation in 1934. The Wanaque development was an out-

posed capacity of the reservoir and aqueduct was doubled to provide an anticipated 100-mgd supply. Experience in the dry 1930's and 40's indicated the safe yield to be something less than 100 mgd, and works for di-



Fig. 2. Salem-Beverly Water Supply System

This project was established in 1913. It now supplies an average of 7.5 mgd.

growth of a request by Newark and Paterson that the commission build a 50-mgd supply to meet their growing water needs. Within a short time several other communities petitioned to be included in the project, and the pro-

verting water from the Ramapo River to augment the yield were finished in 1954.

The system consists of a 30-bil gal reservoir on the Wanaque River and an aqueduct 20 mi long to the Belle-

ville Reservoir of the Newark water works. The aqueduct has a capacity of 150 mgd between Wanaque and Little Falls; from Little Falls to Bloomfield, 105 mgd; and from Bloomfield to the Belleville Reservoir, 97 mgd. The total cost of the original project

tenance costs in recent years have ranged from \$800,000 to \$1,000,000. The original debt is largely paid off and fixed charges are moderate.

4. *Saginaw-Midland water supply.* The Saginaw-Midland system (Fig. 4) is a raw-water supply system that

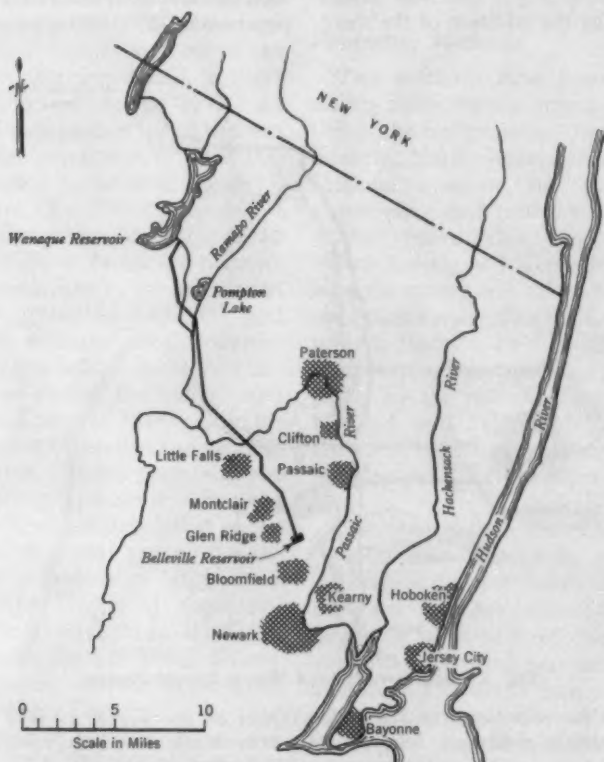


Fig. 3. North Jersey District Water Supply System

The commission was established in 1915, and the Wanaque development went into operation in 1934.

was approximately \$30,000,000. The Ramapo diversion works cost an additional \$5,000,000.

The Wanaque system is operated at capacity and currently furnishes about 100 mgd. Operating and main-

furnishes Lake Huron water to the cities of Saginaw and Midland, Mich. It was completed in 1948 at a total cost of approximately \$12,000,000. The joint facilities consist of an intake at Whitestone Point, 48 mi of 48-in.

diameter concrete pipe, and three pumping stations. The southernmost pumping station, about 13 mi east of Midland, discharges into two 36-in. feeder mains, each about 13 mi long, owned separately by Saginaw and Midland. The initial capacity of the system was 43 mgd; this was raised to 52 mgd by the addition of the third

to Midland's 36-in. feeder main. The Dow Chemical Co. agreed to buy a minimum of 7 mgd when the joint project was undertaken, and this contract made it possible for Midland to finance its share of the project.

Operating and maintenance costs for the Saginaw-Midland system total approximately \$300,000 a year and fixed



Fig. 4. Saginaw-Midland Water Supply System

This project was completed in 1948. It supplies an average of 30 mgd and has a maximum capacity of 52 mgd. A proposed new booster station is expected to increase the maximum to 70 mgd.

pumping station, about 25 mi southwest of the intake. A booster station proposed to be built between the intake and the third pumping station is expected to increase the capacity of the pipeline to 70 mgd.

More than one-half of the water taken by Midland is used by the Dow Chemical Co., which has a connection

charges \$370,000. The average total pumpage is currently 30 mgd.

5. *Metropolitan Water District of Southern California.** The largest regional water supply in the United

* A map of the Metropolitan Water District of Southern California appears in the article by R. B. Diemer, p. 1122 of this issue.

States is the Colorado River system of the Metropolitan Water District of Southern California. This project is 242 mi in length and includes five pumping stations with a total lift of more than 1,600 ft, a 1,100-mgd aqueduct, a 200-mgd filtration and softening plant, 300 mi of distribution mains, and several reservoirs. It is one of the outstanding water supply systems of the country. It was authorized in 1931 and went into operation in 1941. At that time the district included thirteen cities, a total population of 2,000,000 and an assessed valuation of about 1.8 billion dollars. By 1956, the number of member agencies was 23, including 50 incorporated cities (some participants include several cities); the population served had grown to 6,432,000, and the assessed valuation of the district was almost ten billion dollars. During the same period, the annual consumption of Colorado River water increased from 400 acre-ft to more than 400,000 acre-ft. Rapid growth of the Colorado River system is accounted for by the increased population of the original member cities and by the annexation of a number of large water districts. The largest of these districts are the Central Basin Municipal Water District, the San Diego County Water Authority, and the West Basin Municipal Water District.

The district's facilities have cost more than \$300,000,000 to build, of which about one-third has been spent for distribution mains, reservoirs, and the softening plant. At the present time, 40 per cent of the water is sold without treatment and 60 per cent is filtered and softened. Operating and maintenance costs have increased with the greater use of Colorado River water and totaled \$4,300,000 in 1955-56. In the same year, tax pay-

ments to the district for interest and amortization and new construction and annexation charges exceeded \$24,000,000. Water deliveries to members and a number of contract purchases totaled 235,000 acre-ft of raw water and 171,000 acre-ft of filtered water.

Financing Methods

Two methods have been used for raising funds for the original construction of the five projects. In the Salem-Beverly, North Jersey, and Saginaw-Midland systems, the participating communities each contributed a portion of the construction fund. In the Salem-Beverly and North Jersey projects, the money was raised by general-obligation bonds. For the Lake Huron project, Saginaw paid its share partly from water department surpluses and partly by the sale of revenue bonds; Midland sold revenue bonds for its share. These three systems are the joint property of the cities that built them.

The Metropolitan District of Massachusetts was financed by the sale of full-faith-and-credit bonds backed by the state. Member cities of the district have paid all of the fixed charges, however, plus operating expenses, through assessments collected each year by the state treasurer. The Metropolitan District of Southern California is a separate corporate body and has issued its own general-obligation bonds. These bonds are backed by the power of the district to levy *ad valorem* taxes on all property within it. Taxes are collected each year from the member municipalities and water districts through the several county treasurers.

Additions to the Massachusetts Metropolitan District project have been financed by the sale of bonds, as re-

quired. The \$70,000,000 spent for the Quabbin Reservoir and aqueduct has been the chief expenditure since the original works were taken over. Additions to the original Salem-Beverly system, consisting of a filter plant and a third reservoir, have been financed through direct contributions by the two cities, with funds raised by general-obligation bonds. In the North Jersey system the Ramapo River pumping station and pipeline, costing \$5,000,000, was paid for out of contributions by the seven cities owning the Wanaque supply. The pumping station added recently to the Saginaw-Midland system was paid for partly by contributions from the cities and partly from a \$100,000 fund built up during the first few years of operation by means of a one-half cent per 1,000 gallons surcharge.

Funds for the extensive additions to the Southern California water system have been obtained in three ways:

1. *Ad valorem* taxes on property within the district
2. Accumulated annexation funds paid to the district by members who have joined since it was organized
3. Sale of general-obligation bonds by the district.

Allocation of Costs

1. *Metropolitan District of Massachusetts.* The methods of financing and cost allocation in the Massachusetts Metropolitan District have been revised from time to time. There were a few minor changes in the law immediately after the district was formed, but the annual assessments of the members were fixed to cover all costs, including interest and sinking-fund payments, maintenance, and operation. One-third of the annual payment was in proportion to the assessed valuation of the

member cities and two-thirds in proportion to the water consumed by the members in the previous year. This procedure was followed until 1946, when the charges were reduced to \$40 per million gallons taken from the district, regardless of assessed valuation. The rate was raised to \$80 per million gallons in 1953. Factors involved in the changes in the Massachusetts procedure will be described more fully when annexation of new areas is discussed.

2. *Salem-Beverly.* The legislation authorizing the Salem-Beverly system provided that Salem pay two-thirds of the construction cost and Beverly one-third. Each city sold its own bonds for its share of the works, and each has taken care of its own interest and amortization costs. The enabling act stipulated that operating costs for the first 5 years be similarly divided, with a provision that these costs be reallocated at 5-year intervals by the board, or by three nonresident arbitrators if the board could not agree. Actually, the original allocation has been maintained throughout without change, and each city has been assessed its share of the operating and maintenance costs on that basis.

3. *North Jersey.* The construction costs of the North Jersey District were allocated to the participating municipalities by the initial contract as follows: Newark, 40.5 per cent; Paterson, 20.0; Kearny, 12.0; Passaic, 11.0; Clifton, 6.75; Montclair, 5.0; Bloomfield, 4.0; and Glen Ridge, 0.75. Paterson, Passaic, and Clifton subsequently formed the Passaic Valley Water Commission, which acquired their allotment in the Wanaque system.

The basis for the allocation is not entirely clear from the records and apparently was reached by compromise

and agreement. The allotments agree reasonably well with the population of the cities at the time the district was formed, however, with the exception of Kearny, which had a number of large industrial water users.

Each of the participants in the North Jersey system has paid interest and amortization on its share of the initial construction, and these costs do not appear in the district records. Operating expenses are assessed each year in proportion to the original allotments, regardless of how much water is consumed by each city. The assessments are adjusted each year to correct differences between the assessment and actual cost for the previous year, but these adjustments are relatively minor.

The proportion of operating costs paid by each city in the North Jersey system is influenced indirectly by the distribution of income received by the district from the city of Bayonne. Bayonne had been expected to participate in the project, but withdrew at the last moment. Bayonne has, however, bought on a contract basis about 10 mgd from the district ever since the Wanaque system went into operation. Bayonne has paid rates which have gradually increased from \$70 to \$95 per million gallons. The income from Bayonne in recent years has been about \$340,000, more than 40 per cent of the district's operating expense. In distributing this income to the owners of the Wanaque system, both the original percentage allotment and the amount of the allotment not actually used are taken into consideration. In this way, the net cost of operation and maintenance for each city is adjusted to correspond, approximately, to the actual use of Wanaque water.

4. *Saginaw-Midland.* The original cost of the Saginaw-Midland system

was divided about 53.6 per cent for Saginaw and 46.4 per cent for Midland. This reflected water consumption when the works were undertaken. The Midland allotment included the 7 mgd which the Dow Chemical Co. agreed to buy. The agreement between Saginaw and Midland provided that if the cost of money for the two cities differed by less than 0.5 per cent, the fixed charges would be added to the operating and maintenance costs, and the total cost would be allocated in proportion to the water consumption. In fact, the interest rates have differed by only 0.27 per cent.

5. *Metropolitan District of Southern California.* The cost of building the Metropolitan District works in Southern California has been allocated in proportion to the assessed valuation of the member cities and water districts. A substantial part of the construction funds were raised by *ad valorem* taxes on the property in the district, and money for interest payments and amortization of construction bonds was also obtained in this way. The price for water has been fixed arbitrarily to cover operating and maintenance expenses. From 1941 to 1948 the sales price for unsoftened water was \$8 per acre-foot, and for softened water, \$15 per acre-foot. At present, the rate between May 1 and Nov. 30 is \$10 per acre-foot for raw water and \$22 for softened water; for the period from Dec. 1 to Apr. 30, the rate is \$8 for raw water and \$18 for softened water. The water rates are fixed to cover all operating and maintenance expenses, with a safe margin for repairs, capital replacements, and contingencies, but they are not expected to finance the construction of new works.

6. *Effect of member location on costs.* In these water systems, there is practically no differentiation in charges because of the relative location of members. In the Salem-Beverly and Saginaw-Midland systems, there is no need for any adjustment, since the participants are served equally. In the North Jersey system all members contributed to the cost of the aqueduct, as far as Little Falls. Below Little Falls, where water is taken from the aqueduct for Passaic, Paterson, and Clifton, the cost of the aqueduct was paid by the other member cities. The total cost of the aqueduct below Little Falls was about \$3,000,000, or less than 15 per cent of the project cost, and this adjustment has had little effect on overall water costs.

No distinction has been made between member cities of the Massachusetts Metropolitan District, although at one time consideration was given to different rates for Wachusett and Quabbin water. There is a special low rate for Chicopee and other communities west of the Quabbin Reservoir, but Boston and its suburban communities pay equal rates. The enabling legislation setting up the Metropolitan District of Southern California prescribed that the same rates be charged all members for water. This perhaps favors Los Angeles and some of the older members near the coast at the expense of the later inland participants. Many of these later members take raw water for irrigation purposes, however, and conditions are not directly comparable. When San Diego was annexed, the district agreed to finance only the upper third of the branch line to San Diego. The San Diego Water Authority paid for the rest.

Annexation of New Areas

1. *Metropolitan District of Massachusetts.* The 1895 legislation defined the Massachusetts Metropolitan District as the area within 10 mi of Boston. Twelve communities joined the district immediately for water supply service; Newton was an original member, but for standby water service only; seven more communities joined the district within the next 15 years. The latecomers were required to pay an entrance fee based on a proportionate share of the sinking fund at the time they entered the system. Expenditures and sinking fund accumulations were relatively small in the early years, and most of the entrance fees were less than \$30,000. Swampscott, however, paid a fee of \$90,000 when it joined in 1909. There were no further additions until 1925, when Brookline joined the district on payment of an entrance fee of \$400,000. By 1920 the sinking fund totaled nearly \$17,000,000, and the entrance fee became prohibitively high for most communities. Furthermore, the total water demand was fast approaching the safe yield of the district supply, and there was little incentive to extend the area served.

The Quabbin Reservoir and aqueduct, built in the 1930's, increased the safe yield to 330 mgd. Within a short time, changes in methods of financing and cost allocation were proposed in order to encourage greater use of the Quabbin supply and to reduce the cost of water to the participating districts. In 1943 the Metropolitan Water District was extended to 15 mi from Boston. Standby water service charges were cut in half, entrance fees were eliminated, and a water price of \$75

per million gallons was fixed for eligible nonmembers. Two years later, standby water service charges and the price differential between members and nonmembers were eliminated, and all takers were charged \$40 per million gallons regardless of assessed valuation. The 1945 legislation provided that the difference between the total costs and revenues derived from the \$40 charge be made up by the sale of water-use development bonds. It should be noted that the Quabbin Reservoir and aqueduct construction was financed with 30-year serial bonds, which had an average maturity of only 15 years. The works will have an almost indefinite life, certainly well over 100 years, and short-term financing would impose an unreasonable burden on the water consumers. Refinancing extended the amortization over a more reasonable period, thereby justifying, to some extent, the deficit-financing methods used. A rate of \$50 or \$60 per million gallons would also have accomplished this, proving that the \$40 rate was too low. The rate was raised to \$80 per million gallons by the legislature in 1953, to bring costs and revenue more closely into line.

The district has also extended its service westward to serve the city of Chicopee and other communities in that region. These municipalities are charged special, graduated rates, ranging from \$60 down to \$40 per million gallons, depending upon consumption. The rates are set to cover the cost of water from the Quabbin Reservoir, plus the cost of the pipeline built to serve these communities.

2. Salem-Beverly. There has been no intent or need to extend the Salem-Beverly system. The enabling legislation provided that the: "water supply

board may, on equitable terms, furnish and sell water to the towns of Wehnam and Hamilton," in which some of the joint facilities are located. The stipulation evidently was included to allay the fears of these communities that they might lose a source of supply which they would need later. Actually, the Salem-Beverly Board has not been asked to serve these towns.

3. North Jersey. No provision has been made for extending the Wanaque water supply to additional participants. On the contrary, the original agreement provides that each participant retain indefinitely its share of the total capacity. The commission has sold for many years, out of surplus water, about 10 per cent of the Wanaque output to Bayonne. In recent years, a number of the participating cities have sold water through their systems to other communities and water companies, so that Wanaque water has been used beyond the original boundaries of the project. The Wanaque system is used to capacity now, and the absence of excess water makes academic the extension of the system at the present time.

The original 1915 legislation required that all communities in the twelve counties within the North Jersey District obtain permission from the commission prior to developing additional water supplies for their own use. It was anticipated at that time that the further development of water supplies in the area would be along regional lines. Actually, with the exception of a few major systems like the Passaic Valley Water Commission system, the Newark system, the Hackensack Water Co. system, and the Jersey City works, growing water needs have been chiefly met by the development

of a large number of small, independent municipal supplies, chiefly from wells.

4. *Saginaw-Midland.* The Saginaw-Midland water supply system was designed primarily for these two cities,

compares with the retail rates for filtered water in Saginaw and Midland. The Dow Chemical Co. takes 7-9 mgd of raw water, for which it pays Midland the actual cost, plus 1 cent per 1,000 gallons.

TABLE 1
Consumption and Assessments for the Metropolitan District of Massachusetts, 1930-56

City	Year	Population	Assessed Valuation	Water Consumption	Annual Assessment*
		per cent of total			
Boston	1930	52.1	64.5	66.2	65.6
	1940	51.0	58.9	64.8	62.8
	1950	50.2	53.3	63.5	63.0
	1956	44.0	46.5	56.2	57.2
Somerville	1930	6.9	3.9	6.1	5.3
	1940	6.8	4.4	6.6	5.9
	1950	6.4	4.4	6.0	6.2
	1956	6.0	4.0	4.8	5.0
Quincy	1930	4.8	4.6	4.0	4.2
	1940	5.0	4.7	3.3	3.8
	1950	5.2	5.0	4.0	3.8
	1956	5.3	5.0	3.6	3.7
Medford	1930	4.0	2.6	2.4	2.4
	1940	4.2	3.0	2.5	2.7
	1950	4.2	3.1	2.3	2.2
	1956	4.1	3.1	2.7	2.7
Malden	1930	3.9	2.3	2.6	2.5
	1940	3.9	2.7	3.0	2.9
	1950	3.8	2.7	2.8	2.7
	1956	3.7	2.7	2.5	2.7
Everett	1930	3.2	2.4	3.6	3.2
	1940	3.1	2.8	3.3	3.1
	1950	2.9	3.2	4.6	4.4
	1956	2.8	3.2	4.1	4.0

* Cost allocation procedure was changed in 1946.

with no intention to sell substantial quantities of water to others. Approximately one-half of one per cent of the total pumpage is sold to customers along the transmission line. The price of raw lake water is fairly high, and

5. *Metropolitan District of Southern California.* The Southern California district has been extended frequently, and each municipality or district joining it has been required to pay substantial annexation charges. There is no

statutory formula, but in practice the policy of the board has been to require each annexed area to pay an amount equal to what would have been derived through tax levies had the area been a part of the district from the beginning. This amount, plus interest, may be paid in a lump sum, but is customarily paid over a 30-year period in equal annual installments. The magnitude of these payments is indicated by the fact that nearly \$16,000,000 in annexation charges had been paid up to 1956, and

to 1956 Los Angeles' share has dropped from 69.2 per cent to 36.1 per cent; Long Beach has dropped from 9.0 to 4.5; Glendale, from 3.5 to 1.8; Pasadena, from 3.9 to 2.1. The works and their capacity have been increased substantially by additional construction, however, so that the value of each member's share is larger today than it was when the Colorado River supply first went into operation.

In comparing the experience of the Massachusetts district with that of the

TABLE 2
Consumption and Assessments for Salem and Beverly, 1915-55

City	Year	Population	Assessed Valuation	Water Consumption	Annual Assessment
		<i>per cent of total</i>			
Salem	1915	62	47	70	67
	1920	65	52	78	67
	1930	63	55	77	67
	1940	61	57	70	67
	1950	59	57	69	67
	1955	56	61	63	67
Beverly	1915	38	53	30	33
	1920	35	48	22	33
	1930	37	45	23	33
	1940	39	43	30	33
	1950	41	43	31	33
	1955	44	39	37	33

a balance of more than \$170,000,000 remains to be collected.

As each new member is admitted, its share of the district taxes is assessed in the same way as for the older members. The share of each member city or district in the capacity of the system is determined by its tax payments over the years, which in turn are based on assessed valuation of property. Extending the district has had the effect of reducing the proportionate share of the original member cities. From 1945

Southern California district, it is important to keep in mind that the growth of the area around Los Angeles has been dependent upon Colorado River water and that the member communities have had little choice other than to join the district. In Massachusetts, the local water supplies are limited but have been adequate to meet the demands of many of the suburban communities. The pressure upon these communities to join the system has, therefore, been much less. The assess-

ment of annexation charges comparable to those paid in Southern California would not be acceptable in Massachusetts, or other eastern states, where the rainfall and water resources are comparatively well distributed.

each member are expressed in percentage of the total for the entire system, including the members not listed. For the Metropolitan District of Massachusetts the six largest communities are shown; for the Metropolitan District

TABLE 3
Consumption and Assessments for the North Jersey District, 1940-56

City	Year	Population	Assessed Valuation	Total Water Consumption	Wanaque Water Consumption*	Wanaque Allotment and Annual Assessment†
		<i>per cent of total</i>				
Newark	1940	53.3	46.0	53.2	27.0	40.5
	1950	52.1	43.0	48.4	30.3	40.5
	1956		37.3	49.1	29.3	40.5
Paterson, Passaic, and Clifton‡	1940	30.9	37.3	34.0	51.4	37.75
	1950	31.1	42.1	41.0	39.3	37.75
	1956		47.7	40.0	47.6	37.75
Kearny	1940	4.9	5.0	6.3	10.7	12.0
	1950	4.8	4.8	5.2	15.0	12.0
	1956		4.7	5.5	11.3	12.0
Montclair	1940	4.9	6.0	3.0	5.1	5.0
	1950	5.2	5.1	2.1	6.3	5.0
	1956		4.7	2.0	4.8	5.0
Bloomfield§	1940	5.1	4.5	3.0	5.0	4.0
	1950	5.9	4.0	2.9	8.2	4.0
	1956		4.7	3.1	6.4	4.0
Glen Ridge	1940	0.9	1.2	0.5	0.8	0.75
	1950	0.9	1.0	0.3	0.9	0.75
	1956		0.9	0.3	0.6	0.75

* Excluding sales to Bayonne.

† Before adjusting for Bayonne revenue.

‡ Passaic Valley Water Commission.

§ By interchange with Newark.

Statistical Analysis

Statistical data have been arranged to show, for representative years, the relationship between the participating municipalities and water districts as to population, assessed valuation, total water consumption, cost of water from the regional or joint supply, and quantity of water taken. The figures for

of Southern California the original members and three relatively large districts which joined later are shown.

Consumption and Assessment

The water consumption and cost data given in the tables are generally accurate, and only a few approximations have been necessary. Population and

assessed valuation have been taken from readily available sources, and there undoubtedly are some errors in these figures. The valuation data have not been corrected for differences in assessment procedure, although in some states equalization ratios are available, which should be applied for a more accurate comparison. All of the figures have been rounded off for simplicity; small differences between communities are not significant.

The purpose of the analysis has been to check the relationship of population, valuation, and water consumption—any one of which is a measure of a community's size—and to investigate the changes that have taken place over the years as the member communities have grown. There is danger of oversimplification, but certain observations may be made:

1. With a few easily explained exceptions, the trends in population, assessed valuation, and total water consumption are reasonably parallel, as would be expected.

2. In the Massachusetts system, the suburbs have grown at the expense of Boston. The relative valuation of the five smaller cities increased between 1930 and 1956 (Table 1). In two of these cities the water consumption increased relatively, and in three there was a decrease. The cost of water (annual assessment) paralleled the water consumption, except for Malden, where costs increased relatively in spite of a relative drop in consumption. The decline in Boston's water costs from 65.6 to 57.2 per cent was comparable with the drop in consumption, but was much less than the 18 per cent decline in valuation.

3. Beverly has grown more rapidly than Salem in population (Table 2), but Salem's assessed valuation has in-

creased more. Salem's high percentage of the water consumption was reduced substantially by the installation of water meters prior to 1940. Salem had a cost advantage over Beverly in the early years of the project, but at the present time the ratios of population, valuation, water consumption, and costs are remarkably close.

4. In the North Jersey system, Newark's share of the assessed valuation and total water use increased between 1940 and 1956, but its participation in

TABLE 4
Consumption and Assessments for Saginaw and Midland, 1950-56

City	Year	Population	Assessed Valuation	Water Consumption and Cost
		per cent of total		
Saginaw	1950	82	68	52
	1952		64	51
	1954		63	55
	1956		61	52
Midland*	1950	18	32	48
	1952		36	49
	1954		37	45
	1956		39	48

* Midland water consumption includes raw water bought by Dow Chemical Co.

the Wanaque system increased (Table 3). Kearny's experience has been similar. On the other hand, the increase in assessed valuation and water consumption in the Passaic Valley Water Commission area (Paterson, Passaic, and Clifton) has been accompanied by a relative decrease in Wanaque water consumption. For the three other communities, the trends in valuation, total water consumption and Wanaque water consumption have been about the same.

TABLE 5
*Consumption and Assessments for Certain Members of the Metropolitan District
 of Southern California, 1944-56*

Member	Year	Popula- tion	Assessed Valuation	Total Water Consump- tion	Colorado River Water Consumption	Payments to District*
		per cent of total†				
Los Angeles	1944-45	71.9	69.2	75.1	1.0	66.0
	1950-51	56.2	57.9	54.1	3.8	50.8
	1955-56	35.2	36.1	27.7	9.8	31.1
Long Beach	1944-45	9.2	9.0	6.3	16.2	9.2
	1950-51	7.2	7.7	4.7	8.3	8.2
	1955-56	4.8	4.5	2.4	4.6	4.9
Glendale	1944-45	3.8	3.5	3.3	0.0	3.4
	1950-51	2.7	2.9	2.6	0.2	2.5
	1955-56	1.8	1.8	1.4	0.5	1.5
Pasadena	1944-45	3.7	3.9	4.1	14.5	4.5
	1950-51	3.0	3.5	3.3	10.2	4.9
	1955-56	1.9	2.1	1.7	5.7	3.2
Santa Monica	1944-45	2.6	2.5	2.0	28.8	3.6
	1950-51	2.0	2.3	1.5	6.9	3.3
	1955-56	1.2	1.8	0.7	3.5	2.2
Burbank	1944-45	2.5	3.2	3.1	2.4	3.2
	1950-51	2.2	2.7	2.3	0.2	2.3
	1955-56	1.5	2.0	1.3	0.5	1.8
Santa Ana	1944-45	1.6	1.2	1.2	15.7	1.9
	1950-51	1.3	1.3	1.0	4.1	1.9
	1955-56	1.2	0.9	0.6	1.6	1.1
Beverly Hills	1944-45	1.3	3.0	1.7	8.4	3.3
	1950-51	0.8	2.7	1.2	0.3	2.4
	1955-56	0.5	1.5	0.6	0.8	1.4
Compton	1944-45	1.0	0.6	0.8	1.1	0.6
	1950-51	1.4	0.9	0.6	0.0	0.8
	1955-56	1.0	0.7	0.3	0.0	0.5
Anaheim	1944-45	0.5	0.4	0.5	6.2	0.7
	1950-51	0.4	0.5	0.4	1.6	0.7
	1955-56	0.7	0.4	0.5	1.6	0.7
Fullerton	1944-45	0.5	0.8	0.6	1.6	0.9
	1950-51	0.4	0.8	0.5	1.3	1.0
	1955-56	0.6	0.6	0.6	1.5	0.8

* Annexation payments excluded. Payments include taxes and water sales.

† Includes communities not shown.

TABLE 5—*Consumption and Assessments for Certain Members of the Metropolitan District of Southern California (contd.)*

Member	Year	Popula- tion	Assessed Valuation	Total Water Consump- tion	Colorado River Water Consumption	Payments to District*
		per cent of total†				
Coastal	1944-45	0.5	0.5	0.6	3.9	0.6
	1950-51	1.1	1.7	1.0	2.5	2.0
	1955-56	1.0	1.4	0.6	2.4	1.8
Torrance	1944-45	0.5	1.3	0.8	0.1	1.3
	1950-51	0.6	1.2	0.7	2.1	1.4
	1955-56	1.2	1.3	0.7	3.1	1.7
San Marino	1944-45	0.4	0.8	0.6	0.0	0.8
	1950-51	0.3	0.7	0.5	0.0	0.6
	1955-56	0.2	0.4	0.3	0.0	0.3
Eastern Municipal Water District	1955-56	0.5	0.4	9.6	6.8‡	1.1
San Diego County Water Authority	1955-56	13.1	9.1	9.1	36.8‡	11.7
West Basin Municipal Water District	1955-56	5.6	8.6	5.4	13.3‡	10.4

‡ Raw water.

5. Midland's share of water consumption and cost is relatively higher than its share of the population and valuation (Table 4). Under the present arrangements, if the water demands for one city should outstrip those of the other, the largest city would pay more of the fixed charges and still not change its interest in the works from the original ratio (53.6 to 43.4 per cent).

6. The Southern California district has changed more than the others because of the annexation of large water-consuming areas since the district was founded. With few exceptions, the proportionate shares of the original members have decreased, in some cases substantially (Table 5). For example, Los Angeles' share of the population, valuation, total water consumption, and

payments to the district has declined from about 70 per cent in 1944-45 to less than 35 per cent in 1955-56. For the same period, Los Angeles' use of Colorado River water has increased from 1 to 9.8 per cent of the total pumped. More important to Los Angeles, however, is the fact that, although the capacity of the Colorado River system has been increased by the addition of pumps, reservoirs, and a softening plant, Los Angeles' proportionate share in this capacity has decreased by nearly half. The other original members report proportionate decreases; some, however, have used relatively more or less Colorado River water. On the other hand, some of the newer members with relatively small populations and valuations are taking relatively

large quantities of water, usually raw water. These new members are using available capacity and are paying for the water by means of rates. They will not establish a permanent right to large quantities of water unless and until their assessed valuation and tax payments to the district entitle them to it. Water sales account for less than 20 per cent of the district's total income;

TABLE 6

Percentage of Water Used Obtained From Regional System

City	Water Obtained—%		
North Jersey District	1940	1950	1956
Newark	30.3	22.0	28.7
Passaic, Paterson, and Clifton*	90.0	33.5	57.5
Bloomfield†	100.0	100.0	100.0
Kearny	100.0	100.0	100.0
Montclair	100.0	100.0	100.0
Glen Ridge	100.0	100.0	100.0
Southern California District‡	1944-45	1950-51	1955-56
San Marino	0.0	0.0	0.0
Glendale	0.0	1.4	6.1
Los Angeles	0.9	1.4	6.5
Long Beach	17.7	35.1	36.0
Pasadena	24.4	62.0	61.9
San Diego		81.7	74.1
Santa Monica	99.4	92.5	91.6

* Passaic Valley Water Commission.

† By interchange with Newark.

‡ Selected representative cities.

more than 80 per cent is obtained by means of taxes.

Cost Allocation

Cost allocation should allow for the services the regional system performs. If it furnishes all of the water requirements of its members, as do the Salem-Beverly and the Saginaw-Midland systems, and also, for practical purposes, the Massachusetts Metropolitan system,

costs might reasonably be allocated on the basis of water consumption, assessed valuation, or even population. On the other hand, systems like the North Jersey and Southern California are largely supplemental. As shown in Table 6, Newark has met about 25 per cent of its demands from the Wanaque system, and the rest from its own sources. The Passaic Valley Water Commission's use of Wanaque water has varied widely; the four smaller North Jersey communities have obtained all of their water from the North Jersey system.

In Southern California, some communities use the Colorado system entirely for standby or emergency service. Los Angeles, although it pays more than a third of the bill, consumes only 10 per cent of the total water produced by the system. This water is 6.5 per cent of the total consumption in Los Angeles. San Diego relies on the district for more than 70 per cent of its raw water needs, and some smaller communities for even a higher percentage (Table 6).

The North Jersey and Southern California systems have furnished a standby source of supply in addition to regular local sources and have provided for growing water demands beyond the capacity of the local works. The joint facilities they provide have taken the place of independent supplies, which each community would have had to build for its own protection and growth. Those communities relying on a regional system derive great value from it, whether or not they take much water at the present time. The only way many communities can pay for their share of this value is by assessment on some basis other than use.

The Massachusetts system, in the original legislation, set one-third of the

payment on the basis of assessed valuation and two-thirds on water consumption. In the Salem-Beverly and North Jersey systems, agreed-upon percentages were adopted at the start, and the members have paid their allotted shares regardless of how much water they have taken. In Southern California, a large part of the Colorado River water cost is raised directly by taxation. This procedure is well suited to the region, where land has little value without water, and where water is needed, even in the rural areas, for irrigation purposes.

In the eastern states it would be difficult, if not impossible, to go as far as the Southern California Metropolitan District has gone. It will be a long time before rural and suburban areas, which logically should be included in a district, will need water enough to pay heavy assessments. Irrigation is growing rapidly throughout the East, however, and water demands in some areas may eventually approach those of Southern California. In any event, cities which are joining together in the development of a regional water supply should consider cost allocations based on factors other than water consumption.

This approach is consistent with the philosophy of a joint committee of the ASCE and of the American Bar Association (1). The ASCE joint committee urged that part of the cost of water and sewer utilities be charged to property owners, whose property is enhanced by the availability of water and sewer service, whether or not they use the service. This position differs from conclusions reached by the AWWA committee on water rates (2) which recommended that water costs be covered chiefly by water rates. The AWWA committee recognized that nonusers

should pay for fire protection and special services and that water main extensions are often financed by assessment. It also recognized the suitability of taxes for financing water projects in undeveloped areas. For the most part the AWWA report deals with the cost of service to normal customers in existing municipal water systems for which the cost of additions and improvements is not excessive.

Recommendations

The author is aware of the desirability of making water projects self-supporting, and recognizes that in most communities it is easier to raise water rates than to raise taxes. In a number of communities the city officials insist that the water department be put on a self-supporting basis. In the author's opinion, however, the financing of regional water supply systems should reflect the value of a long-range program to everyone in the area served, whether or not they are presently water users. All of the people in the area should contribute to the capital costs of the works. Operating costs should be charged to the users, particularly where pumping and purification expenses are substantial.

This discussion is concerned with payment for joint facilities by member communities and not with how these costs are distributed inside the member districts and municipalities. There has been no opportunity to examine the water department financing in all of the municipalities served. It can be said, however, that nearly all of the municipalities in the systems considered, except the Southern California system, presently collect enough revenue from water rates to pay their share of the joint facilities. In the Southern California system, member districts are

permitted to pay their assessment from funds other than taxation, if they so elect, and one or two districts have done this. This is exceptional, however, and most of the expense is obtained through taxation.

If it is logical that communities pay their share of the standby, or future growth, value of the regional water system, as the author believes, then it is logical that the nonuser of water in each community also contribute. Mu-

sion main to a storage reservoir at Kernersville. The proposed general location of the project is shown in Fig. 5. The first stage of the Yadkin River project was estimated to cost \$16,000,000, exclusive of distribution mains. It would have an initial capacity of 30 mgd and would be designed to permit economical expansion up to 75-mgd peak capacity. It is assumed that the participating cities would continue to use their local supplies but,

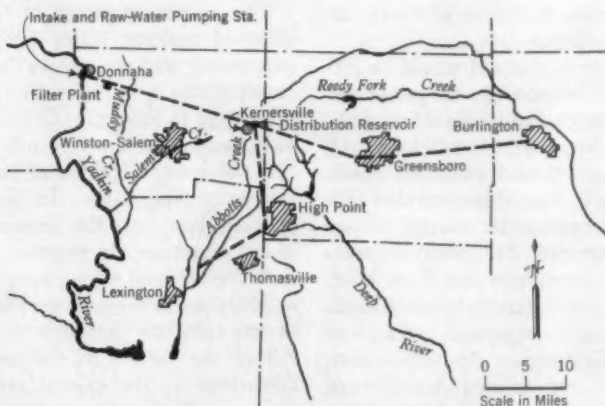


Fig. 5. Proposed Water Project for Yadkin River Area, North Carolina

The map shows the proposed general area of the Yadkin River project and of the seven municipalities it would serve. The heavy broken line represents the proposed water transmission main. The lighter broken lines are county lines.

municipalities considering such joint facilities should take this into account and not necessarily assume that all costs must be covered by water rates.

Yadkin River Project

The Yadkin River, N.C., project (3) favored by the engineers would consist of an intake dam and raw water pumping station on the Yadkin River near Donnaha, a filter plant near the intake, and a filtered water transmis-

sion main to a storage reservoir at Kernersville. The proposed general location of the project is shown in Fig. 5. The first stage of the Yadkin River project was estimated to cost \$16,000,000, exclusive of distribution mains. It would have an initial capacity of 30 mgd and would be designed to permit economical expansion up to 75-mgd peak capacity. It is assumed that the participating cities would continue to use their local supplies but,

except for certain facilities already under construction, that local works would not be enlarged beyond their capacity at the time of the project report (3). The report was preliminary in nature and the final allocation of costs between the participating cities was not specified. A tentative procedure was adopted, however, for comparing the relative costs to be paid by each city:

TABLE 7

Estimated Water Consumption and Yadkin River Pumpage, 1980

City	Total Water Consumption	Yadkin River Water Consumption	Average
	per cent of total		
Burlington	8.9	2.2	5.55
Greensboro	30.8	33.3	32.05
High Point	15.1	20.3	17.70
Kernersville	1.1	0.7	0.90
Lexington	4.9	2.2	3.55
Thomasville	4.1	3.7	3.90
Winston-Salem	35.1	37.6	36.35

1. The estimated total water consumption in each city by 1980, and the amount of water that would be pumped from the Yadkin River to serve that city, were taken as starting points. It was anticipated that the project would not be built for several years, and 1980 seemed an appropriate year to reflect conditions over the first 10 or 20 years of operation.

2. Operating costs were to be charged in proportion to the water supplied to each city from the Yadkin River.

3. Fixed charges were to be allocated on the basis of the estimated average of the total water consumption in each city and the amount of water it would take from the Yadkin River. The results of these estimates are shown in Table 7. The differences between total consumption and Yadkin River water were not large in respect to the three principal cities (Greensboro, High Point, and Winston-Salem), but were appreciable for the smaller communities.

The proposed cost allocations correspond reasonably well to the population, water consumption, and assessed

valuation in Greensboro, High Point, and Winston-Salem, in recent years (Table 8). No adjustment was made for the fact that Winston-Salem would not use the transmission main as much as the other cities, on the theory that Winston-Salem still would be dependent upon the Kernersville reservoir, particularly during the early years of the system, when full-time operation might not be necessary. Subsequent studies for Greensboro and High Point have indicated that these cities can extend their local supplies for at least another 10-15 years at substantially less cost than their payments to the Yadkin River system. Winston-Salem already takes water from the Yadkin River, and it is close enough to make further extensions at relatively low cost.

The author believes that the Yadkin River Project will be completed before the end of the century. It will be built

TABLE 8

Population, Valuation, and Consumption for Three Largest Cities of Yadkin Project, 1940-55

City	Year	Popu- lation	Assessed Valuation	Water Consump- tion
		per cent of total		
Greensboro	1940	34	39	32
	1945	35	37	36
	1950	37	37	38
	1955	38	43	34
High Point	1940	21	18	20
	1945	21	18	20
	1950	20	19	20
	1955	19	21	18
Winston-Salem	1940	45	43	48
	1945	44	45	44
	1950	43	44	42
	1955	43	36	48

when the small streams serving Greensboro and High Point are fully developed, either for water supply or for the dilution of increased quantities of waste from these growing communities. Perhaps the greatest benefit of the Yadkin River system will be the opening up of the unincorporated areas between the cities that now have inadequate water supplies. This is most likely to be accomplished if some way can be found to allocate part of the project costs to the counties and rural areas to be served. The procedures finally adopted undoubtedly will depend upon developments in the next few years and upon the value of water in the region for municipal and agricultural purposes.

Acknowledgments

The author acknowledges with thanks the data furnished by H. J.

Toole, Massachusetts Metropolitan District Commission; K. F. Knowlton, Salem and Beverly Water Board; H. L. Gunther, North Jersey District Water Supply Commission; Alfred Eckert, Saginaw-Midland Water Supply System; and Robert B. Diemer, Metropolitan Water District of Southern California. The supplemental information received from a number of water utilities that participate in these supply systems is also acknowledged.

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Control, Preservation, and Allocation of Texas Water Resources

Joint Discussion

A joint discussion presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex.

Water Problems in Texas—T. Carr Forrest Jr.

A paper presented by T. Carr Forrest Jr., Cons. Engr., Forrest & Cotton, Dallas, Tex.

THE problems encountered in the development of water resources in the state of Texas (Fig. 1) are many and varied in nature. Meteorological conditions have a great deal to do with the variations in problems; stream characteristics create problems of their own. In some areas, the problems are inherent in underground supplies and in others in surface supplies.

Underground Water

The greater portion of Texas has underground supplies, which enabled many communities to get their initial start in the production of water for municipal and industrial uses. The sheer economics of developing water from underground supplies, however, dictated the use of these supplies sometimes far beyond what might be considered practical. For example, a well was drilled a few years ago at Garland, Tex., 15 mi east of Dallas, to a depth of 3,600 ft, where Trinity Sand was encountered. The temperature of the water was 125°F and, of course, it was rather high in sodium bicarbonate content and in total solids.

The use of water for irrigation is making heavy demands upon under-

ground supplies, particularly in the high plains area around Plainview and Lubbock. Of the approximately 60,000 water wells in Texas, 25,000 are in this particular area. Water is being withdrawn at a rate in excess of 5,000,000 acre-ft annually. There is a contrast in this between New Mexico and Texas. New Mexico has an excellent law governing the use of underground water. No well can be drilled without state approval, and there are regulations governing how any well may be abandoned. For many years efforts have been made to secure similar legislation in Texas, without success. New Mexico complains that Texas is drilling wells along the state line, just like fence posts. In this particular area the rate of withdrawal has been estimated at several times the rate of recharge, so it is obvious that a day of reckoning is not too far away.

Municipal use has had to compete with irrigation use of this water. Some cities are buying large areas of land outright at prices ranging from \$25 to \$200 per acre, other cities are buying water rights under lands at \$10-\$30 per acre; and in other cases cities are paying a royalty of 1-5 cents

per 1,000 gal. The efforts in the development of underground water seem never-ending; in 1956 a total of 8,000,000 acre-ft was withdrawn from these supplies throughout the state. Water tables are dropping, and municipalities are being forced to develop surface reservoirs to augment the dwindling underground supplies. The use of water for irrigation establishes an economy that must have continuity or

figures constitute mean annual rainfall; frequently conditions develop that cause a wide departure from this mean.) The record frequently reflects drought conditions of considerable severity over a 2-year period; less frequently these droughts extend over 5 years or more. Most of Texas has just emerged from a prolonged drought, which in some areas began in 1950 and did not terminate until 1957. The

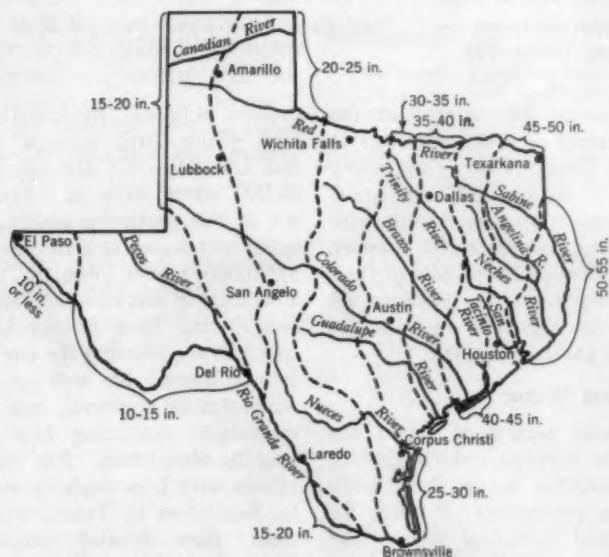


Fig. 1. Rivers and Rainfall of Texas

This map shows the principal rivers and cities of Texas. The dotted lines show the different rainfall areas within the state. Rainfall averages are as of Jan. 1, 1950

face financial chaos when the use of such water proves uneconomical.

Surface Water

In the development of surface supplies, one of the problems is the Texas rainfall, which varies from 47 in. at Texarkana on the east boundary to 9 in. at El Paso on the west. Traveling east in Texas, annual rainfall increases, roughly, 1 in. every 16 mi. (These

official record at Dallas showed a total departure from the mean annual rainfall of 66.5 in. throughout the period of drought which ended in March 1957. Between the end of the drought and January 1958, however, there was a new annual rainfall record of 55.14 in. Two new reservoirs, which had been completed 2 years before the end of the drought, were filled completely. Flood control pools in these same res-

ervoirs were also filled, and spillage began as early as June 1957.

Evaporation and Rainfall

The problem in some parts of Texas is evaporation. Evaporation ranges from 43 in. on the eastern boundary of the state to 67 in. in the western portion. In years of average rainfall the amount of water falling upon a surface supply in the extreme eastern part of the state will be in excess of evaporation. In extreme western parts of the state there will be a net loss through evaporation of 55 in. Yields from surface reservoirs in the western portion of the state are drastically curtailed during a 5-year drought period.

One of the problems of developing a surface supply concerns the difficulty in determining dependable rainfall yields, especially during a 5-year drought. The diminishing yields from east to west are a factor in this. In the Dallas area of the state, for example, the mean annual rainfall of 36 in. will produce a little more than 8 in. of runoff. When the rainfall drops to 22 in., the dependable runoff falls to 1 in. In order to have a sustaining supply through such a prolonged critical period, reservoirs must be developed to contain storage equal to about 5 years of consumption.

Another problem is the rainfall-runoff relationship. Obviously, the decreased rainfall in the western part of the state produces a corresponding decrease in runoff and there is a shrinkage from 13 in. of runoff in the eastern part of the state to less than 1 in. in the west (based upon mean annual conditions). These averages are, of course, vitally affected by prolonged droughts.

In determining yields, especially at the end of prolonged drought periods, complications have arisen in the past

few years which affect the accuracy of such determinations. For many years the prevailing law in the state with respect to small ponds or lakes gave the landowner the right to impound up to 50 acre-ft without filing a permit. A few years ago the legislature arbitrarily raised this to 200 acre-ft. Throughout the state there are now thousands of stock ponds and small reservoirs constructed by farmers, ranchers, and the US Soil Conservation Service. There is no record of the number of these, their capacity, or the amount of water they use. A number of such reservoirs on a watershed will have a depleting effect upon the runoff which finds its way into municipal reservoirs during periods of sustained drought. This means that the old stream-flow records can no longer be accepted at face value. A complete reevaluation must be made of reservoir yields. It is certain that these yields cannot be depended upon for the life that was originally anticipated.

Increased Use

Another problem is the increasing use of water and the rate of use, which varies from average conditions to summer peaks. Within the past three decades it has been observed that per capita consumption has increased from 75 to as much as 140 gpd average use. In the summer months the peak demands now run to 280 gpd, and the peak hours develop demands of over 500 gpd per capita.

The rivers in the northeastern part of Texas flow in an easterly direction and all combine in the Red River in the state of Louisiana. The Canadian River flows easterly across the Panhandle. All other rivers have common characteristics: they originate in the northern portion of the state and flow in a southeasterly direction, maintain-

ing their individual watersheds all the way to the Gulf of Mexico. The combined flow of the rivers within the state reflects a mean annual discharge of about 38,500,000 acre-ft, of which the greater portion still remains undeveloped. The parallel characteristics of the streams makes it necessary, however, for large metropolitan areas to develop multiple water supply sources, instead of meeting their needs from a single stream.

This points up the problem inherent in the development of sufficient water for the Dallas-Fort Worth area demand, which is rapidly increasing. Within 40 years, Dallas and Tarrant counties are expected to develop an average demand of 915 mgd. In its long-range planning, Dallas is developing the full yield potential of the Elm Fork of the Trinity River above the city, and Fort Worth is doing the same on the West Fork of the Trinity River above that city. These sources are not sufficient, however, and the two cities' quest for water is leading them eastward to the more favorable rainfall and runoff belts. Dallas is presently building a 926,000-acre-ft reservoir 35 mi east of the city, and has plans under way for a 490,000-acre-ft reservoir immediately east of the city which will be largely used for peaking purposes. Fort Worth has plans to develop two reservoirs 80 mi to the southeast. One of these, on Cedar Creek, will store

679,000 acre-ft, and the other, on Richland Creek, will store 1,135,000 acre-ft.

Financial Problems

All of this effort on the part of a metropolitan area means financial problems as well as physical ones. Surface reservoirs are expensive, but it is even more expensive to provide pipeline capacity to utilize the design yields. For instance, the Iron Bridge Reservoir now under construction by the city of Dallas on the Sabine River will store 926,000 acre-ft of water, and will develop a yield of 200 mgd, of which Dallas will be entitled to 160 mgd. The cost of this reservoir is estimated at \$19,500,000. To provide the conduit capacity for 160 mgd will cost approximately \$26,000,000. In the case of Fort Worth, its two reservoirs are estimated to cost \$41,212,000. They will store 1,814,000 acre-ft with an average daily yield of 364 mgd. The cost of providing conduits for this yield is \$69,149,000, or more than 165 per cent of reservoir cost. Obviously, the longer the lines, the more the power cost will be.

The problems discussed in this article are serious, and will become more so as time goes on and population increases, but for the most part they are not insurmountable. The state, river authorities, water districts, and municipalities are all working toward the solution of these problems.

—Action on Texas Water Problems—Marvin C. Nichols—

A paper presented by Marvin C. Nichols, Cons. Engr., Freese & Nichols, Fort Worth, Tex.

Texans have been moving towards a solution of their water problems for more than a century. The solution of these problems has progressed largely through evolution. With each new de-

velopment, the individual has lost some measure of independence in this field. In the days of the Texas Republic (1835-45) the individual solved his own water problems. Later, several

neighbors voluntarily joined together, and private water systems were expanded to serve neighbors at a profit. As the supply and the systems became more complex, villages, towns, and cities developed water systems as community enterprises to deliver water to their residents at cost. This was the generally accepted practice for generations.

Modern Practice

Within the last 15 years a broader approach has developed. Through state legislation, cities and industry can jointly develop water supplies on a larger and more comprehensive scale. This usually takes the form of a district or authority. The district may consist of one or more cities and constitutes a political subdivision. The cities directly own and operate their respective distribution systems. Industry buys water under long-term contracts. Examples of cities which have built surface water facilities through contractual support by industry are: Arlington, with the Texas Electric Service Co.; Longview, with the Southwestern Gas and Electric Co.; Stamford, with the West Texas Utilities Co.; Graham, with the Texas Electric Service Co.; and Electra, with the Waggoner Estate.

Since World War II great progress has been made in the development of surface supplies through the formation of districts composed of several cities. As examples of this trend, the North Texas Municipal Water District and the Colorado River Municipal Water District have been quite successful.

1. The North Texas District, composed of McKinney, Garland, Mesquite, and seven smaller cities, has acquired 100,000 acre-ft of conservation storage in Lavon Reservoir, which was constructed by the US Corps of

Engineers. Water is sold under contract to the city of Dallas and to rural customers. Without such a cooperative undertaking, this area would now be short of water; with it, the area is vigorous and growing.

2. The Colorado River Municipal Water District, composed of the cities of Big Spring, Odessa, and Snyder, constructed Lake J. B. Thomas on the Colorado River, with a water conservation capacity of 210,000 acre-ft. Water is sold to rural customers. Repressuring units operated by the cities of Sacro, Sharon Ridge, and Monsanto purchase water for water-flooding operations in secondary oil recovery. It is estimated that approximately 500,000,000 bbl of oil will be recovered as a result of this operation, which was made possible by water purchased from the Colorado River District.

Water District Programs

Numerous similar districts are in various stages of their proposed development, and their programs are progressing. Among such districts are:

1. The Sulphur River Municipal Water District, composed of the cities of Sulphur Springs, Commerce, and Cooper, is acquiring storage in Cooper Reservoir, which is to be built by the US Corps of Engineers.

2. The North East Texas Municipal Water District, composed of Mt. Pleasant, Marshall, Jefferson, and five smaller cities, is acquiring storage in Ferrell's Bridge Reservoir, which is being constructed by the US Corps of Engineers.

3. The Neches River Municipal Water District, composed of the cities of Jacksonville, Palestine, and Rusk, proposes to construct a reservoir at Blackburn's Crossing on the Neches River.

4. The White River Municipal Water District, composed of Post and

three smaller cities, proposes a reservoir on the White River.

5. The North Central Texas Municipal Water District, composed of Seymour, Haskell, and five smaller cities, proposes a reservoir on Miller's Creek, a tributary of the Brazos River.

6. The West Central Texas Municipal Water District, composed of the cities of Abilene, Albany, Anson, and Breckenridge, proposes to construct a reservoir on Hubbard Creek, a tributary of the Brazos River.

7. The Canadian River Municipal Water Authority, composed of Amarillo, Borger, Pampa, Plainview, Lubbock, and six smaller cities, proposes to contract with the US Bureau of Reclamation for the construction of Sanford Dam on the Canadian River.

8. The Greenbelt Municipal and Industrial Water District, composed of Childress, Quanah, and four smaller cities, proposes to build a reservoir on the Salt Fork of Red River.

Municipal Programs

The larger metropolitan areas of Texas are also solving their water problems. Among these areas are:

1. Dallas, through the Sabine River Authority, is building Iron Bridge Reservoir on the Sabine and contemplates construction of Forney Reservoir on East Fork of the Trinity River.

2. Fort Worth has plans to build two large reservoirs in the near future on Cedar Creek and Richland Creek, both tributaries of the Trinity River.

3. Waco is contracting for conservation storage in the new reservoir to be constructed on the Bosque River by the US Corps of Engineers.

4. Corpus Christi, through the Lower Nueces River Water Supply District, is completing Lake Mathis Dam on the Nueces River.

5. San Antonio is seeking a surface water supply on the Guadalupe River, but its efforts to date have been blocked by Guadalupe-Blanco River Authority.

6. Houston expects, in the near future, to develop additional surface water from the San Jacinto or Trinity Rivers.

7. Beaumont and Port Arthur expect to increase their water supply greatly by the completion of the McGee Bend Reservoir on the Angelina River, now under construction by the US Corps of Engineers.

8. San Angelo is contracting with the US Bureau of Reclamation for construction of Twin Buttes Reservoir on the South Concho River.

On the principal intrastate streams of Texas, river authorities have been organized. In some instances the entire stream is covered, in others only a part of the watershed is in the authority. The Trinity River, Lower Colorado River, and Lower Neches Valley Authorities cover only a part of their watersheds. The San Jacinto River, Sabine River, Brazos River, and Guadalupe-Blanco River Authorities, and the Nueces Conservation and Reclamation District cover the entire stream. The Sabine, Canadian, Upper Rio Grande and Pecos Rivers are under interstate compacts. The Rio Grande River is under the jurisdiction of the International Water and Boundary Commission.

Very little has been accomplished in the field of underground water. The Texas Underground Water District Law permits the formation of local districts, which may make rules and regulations for prevention of waste and the spacing of wells. Under Texas law underground water belongs to the owner of the land, but the water is also subject to the law of capture. The

state exercises little or no control over underground water.

As Texas grows its water supply problems become more complex. In progressively solving these problems as individuals and as communities, the citizen may gradually lose complete control of some of the facilities. The individual ceases to be sole owner, and in some instances is no longer the major stockholder. Texas has reached the point where some of its water supply problems must be dealt with at the state level. It is the opinion of the author, however, that permanent ownership of water supplies by the state is neither necessary nor desirable. Certainly, the citizens of Texas believe in local ownership and control.

Recent State Action

Texas has made notable progress in the last several years. In the fall of 1952 Governor Allan Shivers appointed a governor's water committee. This committee made recommendations to the legislature in January 1953. Among the bills passed the most significant were for the creation of: [1] Texas Water Resources Committee, and [2] Water Pollution Advisory Council.

Some ten bills were recommended by the Water Resources Committee to the legislature in 1955. Several were passed, but the accomplishments were far from substantial. The major recommendations were not adopted. Although appropriations for the State Board of Water Engineers were increased from \$250,000 to \$450,000 annually, this appropriation was far from adequate.

Eighteen bills were recommended by the Water Resources Committee to the legislature in 1957. Nine were enacted into law. In the author's opin-

ion two of these bills were of major importance: the Financial Aid Constitutional Amendment (H.J.R. 3, plus its enabling act, H.B. 161), and the Cancellation Act (H.B. 145). A brief explanation of these bills will be of interest.

The financial aid amendment was a constitutional amendment adopted by the voters of Texas, Nov. 5, 1957. Two hundred million dollars in general obligation bonds of the state were authorized, to be known as Texas Water Development Bonds. The funds are to be administered by a new board, to be known as Water Development Board, composed of six members. The author has been appointed chairman of this board.

The proceeds of the state bonds will be used to purchase bonds of political subdivisions, issued for the construction or acquisition of dams, reservoirs, intakes, pumping stations, and supply mains or main canal. The Water Development Board cannot purchase bonds of political subdivisions in excess of \$5,000,000 or one-third of the cost of the project, whichever is the least. The bonds purchased by the board may be junior, or secondary, to the other bonds issued for the project and which will be purchased by private investors. The interest rate on the bonds of political subdivisions purchased by the state cannot be less than the average interest rate on the outstanding state bonds, plus 0.5 per cent. No bonds may be purchased after Dec. 31, 1982. This will be a revolving fund, and will assist in the financing of projects costing in the aggregate in excess of \$600,000,000. It is believed that the program will be completely self-liquidating. After the liquidation of the program begins in 1983, any funds remaining after the final payment

is made on the state bonds are to be returned to the general revenue fund. It will be necessary for the first few years, as the program gets under way, for the legislature to appropriate nominal sums for the fund to meet operating expenses and the initial interest requirements of the first bonds issued by the Water Development Board. This will be done by an automatic appropriation provision in the amendment. It is not expected that the aggregate of these automatic appropriations will exceed \$500,000 over a period of several years. As the program proceeds this will be repaid.

The program is a straightforward business venture in a most important resource, water. It is not a gift or a subsidy program, but will pay its own way. Title to all facilities would be held by a political subdivision. Rules and regulations of the program have been promulgated. Some 40 political subdivisions of the state have requested these rules and regulations, and ten or twelve of them have expressed a definite interest. Two loans have been given preliminary approvals. The offices of the Water Development Board are at Austin, Tex.

It is the author's opinion that no duplication of services will arise between the Water Development Board and the State Board of Water Engineers. The engineer board will pass upon the engineering feasibility of all projects; the duties of the Water Development Board will be primarily financial and legal.

The Cancellation Act provides the State Board of Water Engineers with the authority to cancel unused portions of appropriative permits and certified filings. On some streams all the water is held under permit or certified filings. In many instances only a part of the

water has ever been put to beneficial use, and in some instances no water has ever been used. This act will permit a sensible balance of the actual use or reasonable needs for water. Adequate safeguards are provided for public hearings and no one who can establish a reasonable need for water, covered by a permit or certified filing, will be injured.

Need for Further Action

Nine bills recommended by the Water Resources Committee were not passed by the regular session of the legislature in 1957. At least three of these were of major importance: [1] the Conservation Storage Purchase Constitutional Amendment (S.J.R. 1, plus its enabling act, S.B. 2), [2] the Stream Pollution Control Act (S.B. 4), and [3] water resources planning (S.B. 7).

These bills had rough sledding in the legislature. Generally speaking, opinion had not crystallized on these subjects. It is a fact, however, that to a very large degree the manner in which the objectives of these bills are met will determine how well Texas solves its water problems.

The Stream Pollution Control Act would have established the Texas Stream Pollution Control Board. The board would have been empowered to classify streams as to the degree of purification required or the extent of pollution permitted, and to promulgate and enforce orders to abate pollution. Until such time as the board classified a stream the existing provisions of law relating to pollution would have been applicable. It would appear that the Stream Pollution Control Act would be particularly beneficial to the industrial gulf coast. The bill received a cold reception from the State Board of

Health, and no support from the Texas Fish, Game and Oyster Commission. The problem is serious and increasing, and must ultimately be faced objectively.

Water Planning Act

The regular session of the 1957 legislature failed to pass a water planning act. Governor Price Daniel upon adjournment of the regular session, immediately called a special session for the specific purpose of considering water planning legislation. The legislature passed the Texas Water Planning Act of 1957 (S.B. 1). The salient features of this act are:

1. A water resource planning division is established within the Board of Water Engineers.

2. The Board of Water Engineers is directed to prepare and submit to the legislature a statewide report of the water resources of the state, with a correlation of these resources, and to make recommendations to the legislature for the maximum development of the water resources of the state.

3. The Board of Water Engineers is provided with \$400,000 for topographic mapping for the 2-year period ending Sep. 30, 1959.

4. The Board of Water Engineers is authorized to negotiate with federal agencies for the development and acquisition of conservation storage in reservoirs constructed by the United States. The board may enter into preliminary agreements for this purpose, provided, however, that no such agreement shall be binding unless it is specifically approved by the legislature.

5. A total sum of \$894,240 was appropriated for the Board of Water Engineers (including the \$400,000 for topographic mapping).

At the present time the Texas State Board of Water Engineers in cooperation with US Corps of Engineers, the US Bureau of Reclamation, and the Soil Conservation Service is preparing a "mock-up plan" for the development of the state's water resources. The first draft was scheduled to be completed Apr. 30, 1958.

It is the author's opinion that the legislation passed by the legislature, with the active support and leadership of Governors Shivers and Daniel, constitute progressive action towards the solution of the water problems of Texas. Further action is the responsibility of the citizens and the water officials.

Water Quality Studies in the Arkansas and Red River Basins

—Keith S. Krause—

A paper presented on Apr. 21, 1958, at the Annual Conference, Dallas, Tex., by Keith S. Krause, Asst. Regional Engr., Water Supply & Pollution Program, USPHS, Dallas, Tex.

THE Greek philosopher Thales, who lived 600 years before Christ, may have been scientifically inaccurate when he concluded that water was the ultimate substance—the origin of all things—but he was certainly correct in attaching such great importance to it. The records of the early Egyptians and Babylonians, as well as the Greeks, indicate that their progress and retrogression were closely associated with the availability and utilization of water. Water is as important today as it was in those ancient times. Nowhere are people more conscious of the need for water to support regional growth and development than in the Southwest.

The steadily increasing need for water has put great pressure on those who are responsible for its protection and development. Careful and constant review is necessary to see that the water is being effectively used. In areas where water is short, such as in the upper portions of the Arkansas and Red river basins, the effective use of water has become of major importance. The increasing need for more water of good quality by cities, industries, and agriculture, combined with the depletion of some ground water reservoirs, makes the surface water resources of both basins a vital factor in the continued growth of the regional economy. The estimated 1975 municipi-

pal and industrial water use in the basins is approximately $2\frac{1}{2}$ times that of 1954 as indicated in the report of the Arkansas-White-Red Basins Inter-Agency Committee (1).^{*} On the basis of the increase in use during the last 3 years, this estimate is very conservative. More recent estimates indicate that present domestic and industrial users in the Arkansas-White-Red basins have developed storage, pumping, treatment, and distribution facilities to handle approximately 3.8 bgd (2). According to these estimates, 7 bgd of water will be needed by the year 2000. This prediction is probably a conservative one also.

Need for Improvement

As a limited supply of water must meet the constantly increasing use by people, industries, and farms, the improvement of water quality becomes of increasing importance. The use of water directly from the main stems of the Arkansas and the Red rivers has been far below what might be expected, although both streams have sufficient flow, even during drought periods, to satisfy sizable demands. The quality, rather than the quantity, of the

^{*} Development of the committee is discussed in this issue of the Journal (see page 1175).—Ed.

water in these streams has been the limiting factor. The high mineral content originating from both natural and man-made sources is responsible for the poor quality. The Arkansas-White-Red Basins Inter-Agency Committee report states that the principal problem of pollution in these basins is the high concentration of mineral matter.

An examination of the physical characteristics of the Arkansas and Red basins reveals that, in general, the streams are of good quality in the headwaters but deteriorate as they flow eastward across the plains of Kansas, Oklahoma, and Texas. A band of exposed calcium sulfate, about 40 mi in width, is traversed by both the Red and Arkansas rivers. This outcrop is known as the Blaine formation and extends from Texas into Kansas, a little east of and parallel to the 100th meridian. Extensive oil and gas production begins at the eastern edge of the Blaine formation and extends over much of the remainder of the two basins. The western portion of the basin is underlain with salt at depths varying from outcrops to 1,000 ft or more. Occasional springs from this formation contribute to the mineralization.

Historical data indicate that some streams have always had poor quality water; however, the data also indicate that many streams have deteriorated in recent years.

The US Public Health Service, cognizant of the ever-increasing water needs of the region, the pending water resources development, and the three interstate compacts which are being negotiated, initiated an Arkansas-Red basins water quality conservation study on Jul. 1, 1957, as a part of its responsibility to develop comprehensive

programs for the control of water pollution in interstate streams as provided in the Federal Water Pollution Control Act of 1956 (3). It is believed that the time has come when it must be determined whether or not the waters of these two great streams can be improved qualitatively.

Objectives

The objectives of this study are threefold: [1] the determination of the factors which caused the degradation of the waters of the Arkansas and Red rivers; [2] the identification of waters of varying quality for beneficial uses, including the amount and location; and [3] the formulation of measures or methods for the improvement of the overall water quality.

Some of the methods to be examined in an effort to determine how water quality can be improved include: [1] the removal or control of sources of industrial pollution, including those from oil well brine discharges and salt mining operations; [2] off-stream storage of either high-quality water or very poor-quality water; [3] the possible effects of dilution; and [4] the sealing of geologic formations which are contributing mineralized flows.

Scope

The study will be confined to the Arkansas River Basin between Great Bend, Kan., and Little Rock, Ark., and the Red River Basin above Shreveport, La. This area encompasses the major known sources of natural and man-made pollution. Much of this area is usually classified as a semiarid region with rainfall amounting to less than 12 in. per year in the western regions of the two basins and gradually increasing to 55 in. toward the mouths of the two systems. Runoff at Little Rock during

the water year of 1956, one of the driest on record, was 7,800,000 acre-ft. The combined normal runoff of these two river systems at the same point is approximately 47,000,000 acre-ft.

The study is divided into four phases. In Phase 1, all known documented information will be assembled and analyzed with the objectives in mind. Phase 2 will be devoted to making field studies and to supplementing the information obtained in Phase 1. Phase 3 will include the determination of the practicability and economic feasibility

tion and magnitude of the major sources of mineralization and the mineral loading at important points on the two rivers and their principal tributaries. Additional detailed study, will still be desirable for specific water resource projects, and the states will make further investigations of sources of pollution which are found.

Assistance in maintaining the study on the highest professional level is given by a technical advisory committee of three persons, one each from the US Geological Survey and two from

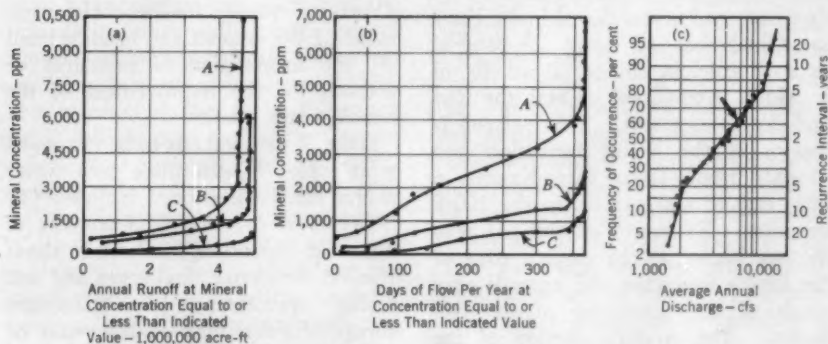


Fig. 1. Cumulative Analysis of Arkansas River Near Tulsa, Okla.

In Fig. 1a and 1b, Curve A indicates total dissolved solids; Curve B, chlorides; and Curve C, sulfates. The arrow in Fig. 1c indicates the frequency of occurrence (63 per cent) expected for the average annual discharge (6,610 cfs) during the period of study, 1947-56.

of possible control measures and the preparation of the study report. Phase 4 is visualized as the implementation of the conclusions reached in the course of the projects studied. This is not considered a USPHS function, but rather a function of the construction agencies. Phase 1 was scheduled for completion on Jun. 30, 1958; the scheduled completion date for Phase 2 is Jun. 30, 1960; and for Phase 3, Jun. 30, 1961.

The investigations made in this study will be sufficient to establish the loca-

tion and magnitude of the major sources of mineralization and the mineral loading at important points on the two rivers and their principal tributaries. Additional detailed study, will still be desirable for specific water resource projects, and the states will make further investigations of sources of pollution which are found.

Observations

Phase 1—the collection, summation, and interpretation of the data—has been completed. Analytical methods were designed to show the yield and quality of water available under present

conditions and to show where the trouble spots are and where more information is necessary. The cumulative frequency distribution analysis was employed to determine the yield of a given quality of water and the number of days per year in which water of this quality can be expected at important stations.

Approximately 250,000 acre-ft of water with less than 500 ppm total dissolved solids flows past Station 259 at Tulsa each year. The water flowing past Station 259 is of this quality, however, less than 1 week each year. The evident conclusion is that although the quantity of good-quality water is large, it occurs during floods, so that the capture of any appreciable amount is difficult.

A check of the chloride concentration shows that at Tulsa about one-half of the annual flow, or 900,000 acre-ft, contains 400 ppm chloride or less. Water of this quality would be usable for numerous purposes, but it occurs only on an average of 50 days in the year. Figure 1 shows the cumulative frequency distribution analysis curves for Station 259 at Tulsa, Okla. Examination of data by this method for each station is being made. This procedure, together with further statistical refinements, will permit estimates of yields and the degree of confidence therein which can be expected under current and proposed controlled conditions.

Calculations of mineral loadings contributed to the Arkansas and Red rivers and their major tributaries have been made for the water year of 1956. This was a year of drought, perhaps the most critical dry year since the Southwest was settled. During this year, the Cimarron River contributed 9.1 per cent of the flow in the Arkansas River as measured at Van Buren, Ark.,

and 18.9 per cent of the total dissolved solids. The Canadian River contributed 16.4 per cent of the flow and 35 per cent of the dissolved solids. In other words, these two streams contributed more than one-half of the mineral loading while providing one-fourth of the flow.

The Arkansas River above Ralston, Okla., contributed 20.8 per cent of the flow and 20.3 per cent of the total solids, while the Grand (Neosho) contributed 26 per cent of the flow and only 5.9 per cent of the solids. The Verdigris River contributed 5 per cent of the flow and 2.1 per cent of the solids, and the Illinois River 6.3 per cent of flow and 0.9 per cent of the solids. The remaining 16.4 per cent of the flow and 16.9 per cent of the solids entered the main stem of the Arkansas River between Ralston, Okla., and Van Buren, Ark.

As the major sources of total dissolved solids are the Canadian and Cimarron rivers, a more detailed examination of these streams is necessary. On the Canadian River, its principal tributary, the North Canadian, contributed 16 per cent of the flow and 31.6 per cent of the total dissolved solids. The Little River at Sasakwa, Okla., contributed 5.1 per cent of the flow and 40.4 per cent of the total dissolved solids. Other sources, including the main stem of the Canadian River above Whitefield, Okla., contributed 78.9 per cent of the flow and 28.0 per cent of the dissolved solids.

These data show that the Little River was the principal source of the dissolved solids while contributing a very small portion of the total discharge of the Canadian River during the water year of 1956. This information indicates the necessity for closer scrutiny of the Little River to determine the sources of the pollution and what might

be done to control them. The reduction of pollution in this stream would result in a significant improvement in the waters of the Canadian River at the Eufaula Reservoir site south of Tulsa and in the Arkansas River below the mouth of the Canadian.

The condition revealed in the Little River is an example of the facts which this study has been designed to establish. Once these are established, the study will be devoted to developing methods for controlling or eliminating the causes of the pollution. The removal or control of 40 per cent of the dissolved solids would undoubtedly be of major economic importance to potential users of water stored in the Eufaula Reservoir near the mouth of the Canadian River which is now under construction by the Army Corps of Engineers.

A start has been made on Phase 2 of the study. A joint field investigation with the Texas State Department of Health of sources of mineral degradation of water in the Wichita and Little Wichita rivers, tributaries of the Red River, was begun in February 1958. The study is already providing useful data and has revealed some major natural and man-made sources of water quality degradation.

Conclusions

Generally speaking, definite conclusions concerning the improvement of overall water quality must await further study; great improvement of the

quality in some streams, however, already appears feasible. The outlook for significant improvement in water quality at key points in the two river systems appears favorable. Other general observations at this time indicate that additional basic data will be necessary before firm conclusions can be drawn and that field investigations to pinpoint sources of pollution will be needed to supplement present knowledge.

The USPHS plans to publish progress reports from time to time containing the summarized information for the use of those agencies, institutions, and individuals having need for the data. The first of these reports was released in June 1958.

Acknowledgments

The USPHS is grateful for and wishes to acknowledge the cooperation of the US Geological Survey in collecting and furnishing basic data and for the technical assistance provided. The interest, cooperation, and assistance of other federal and state agencies are also acknowledged with appreciation.

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Discussion

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In little more than a century there has been a great change in the methods used to investigate water quality.

Methods have progressed from the taste test through spectrophotometry to the radioactive tagging of the chemical components. Because of this progress, it is likely to be forgotten that the concern for water quality did not originate with this generation.

Josiah Gregg, explorer and trader of the 1840's, gave an apt description of the upper Red River Basin when he recorded in his diary (1) that "one of the greatest defects of this country (besides the scarcity of water produced by droughts) is a great natural scarcity on account of the almost absolute lack of constant springs, wherefore the inhabitants are often constrained to the use of water from standing pools, which is very bad."

The study described by the author is dedicated to determining if more water can be made available through pollution abatement. These two basins need more water, particularly in the upper reaches. Each of the states in these basins is promoting industrial development, yet the water quality requirements of industry are often more exacting than those of municipalities. Beyond doubt, industries are avoiding much of this area because of its water quality problems. For example, industries are withholding the building of plants along the Washita arm of Lake Texoma until more assurance is given that the water quality will meet their requirements.

The findings of this study will be important to municipal water users. Oklahoma City would benefit considerably if the program developed from this study improved water quality in the North Canadian River so that water could be diverted to Lake Hefner an additional 60 days per year. Wichita would benefit if water from the Arkansas River could be used for recharge of the Equus beds at times of median and high stream flow.

Minerals

The significance of any program aimed at reducing the mineral solids of water in these two rivers will not be questioned by many who have ex-

perienced the inconvenience of using water of poor chemical quality. For example, officials in Dallas were forced to heroic measures to assure a continued supply of water during the recent drought. Before the water shortage was ended in the spring of 1957, the city was forced to extend a pipeline to the Red River to supplement its dwindling supply. Because the Red River water was highly mineralized, chlorides and total dissolved solids in the tap water reached previously unknown peaks. During a 3-month period in 1956, 67,400 tons of total dissolved solids were pumped into Dallas homes and businesses from this one source. This amount would fill one 5-ton truck each 10 min, day and night. Parked bumper to bumper, a fleet of trucks 47 mi long would have been filled by these mineral solids. By using the latest techniques in mathematics, chemistry, and hydraulics, the water department kept the mineral solids at this level; otherwise, they would have reached much higher levels.

Other studies have been made of mineralized streams. They include one of the mineralized ground water inflow into the Pecos River at Malaga Bend in New Mexico, where the pumping of the mineralized water to an off-stream reservoir offers a costly solution (2). A joint study by the US Geological Survey and Kansas agencies of mineralized flows to the south fork of the Ninnescah River indicated possible improvement by building a relatively short underground dam to impound the mineralized water. The USGS has studied the geologic factors which contribute to mineralization of water in the Powder River and its tributaries (3). These and other studies of natural mineralization have been carried out in connection with specific projects which were proposed for con-

struction. None have encompassed so large an area or attempted the evaluation of all sources of mineralization.

The analysis of the mineral quality problem is made difficult by the intermittent streams in the western end of the two basins. These streams are

When the water stops, however, salt crystals form in the bed of the mineralized streams. These remain until the next freshet redissolves them. Thus, the first flow during a flood is often highly mineralized in spite of the great dilution.

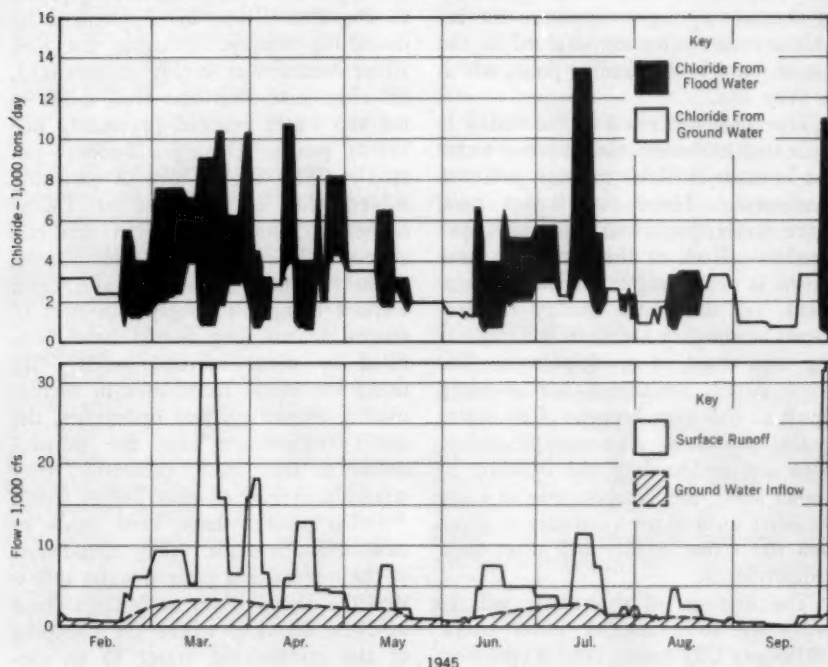


Fig. 2. Sources of Chlorides in the Red River, Gainesville, Tex.

The above is a portion of a hydrograph plotted for a 2-year wet period, 1944-46, and a 3-year drought period, 1952-55. Lower portion estimates the flows from surface runoff and from ground water. Upper portion indicates the amount of chlorides obtained from surface runoff and from ground water accretion.

flashy. Some have wide, deep channels, which carry large volumes during rains, but they stop flowing when the rains end. In areas of salt and gypsum outcrops this is fortunate, for during many days of the year there is no water to dissolve these deposits.

Sources of Pollution

The activities of man in the oil fields, salt mines, and irrigated fields contribute importantly to the pollution of both basins. Some attempts have been made to measure the amounts, but sufficient data to permit an accurate evalu-

ation are not available. In one reach of the Arkansas River, the estimates of man's contribution vary from 10 to 85 per cent of the total load. With such a wide variation, some, and perhaps all, of the estimates are obviously in error.

Irrigation waters increase the mineralization of tributaries of the two rivers. During the process of being used, 20–60 per cent of the water returns to the stream, carrying with it the minerals from the soil and the concentration of solids left after evapotranspiration. Evaporation and transpiration by plants on irrigated land may increase the dissolved solids in the return flow by as much as five times (4).

In studying the mineralization of water in the Saline River in Kansas, Durum (5) developed a procedure of analysis which can be used to estimate the mineral loading from ground water discharging to a gaged stream. The method is more accurate where the ground water contributes nearly all of the dissolved solids than for many of the streams in the Arkansas-Red basins where oil field brine and irrigation add to the mineralized ground water. The method, however, has application to some of the streams.

In an attempt to estimate quantitatively the mineral solids contributed to the Red River at Gainesville, Tex., by ground water inflow and surface runoff, a hydrograph was plotted for a 2-year wet period and a 4-year drought period. The quantity of ground water was estimated using the assumption that surface runoff from any rain is indicated by a substantial increase in the hydrograph. Conversely, low continuous flows were assumed to be ground water infiltration to the stream. On this basis, the low points on the hydrograph were connected, with a slight increase during flood stage to

meet the curve of total runoff. This was in accordance with the principle expressed by Meinzer and Stearns (6): "During the flood stage the discharge of ground water is probably checked, because the water levels of the streams are likely to be higher than the adjacent water table. However, periods of flood runoff are commonly also periods of ground water recharge when the water table is built up. Hence the discharge of ground water is usually greater after a flood stage than it was before the flood." An example of the method used is shown in Fig. 2.

Calculations for 1944–45 show that 55 per cent of the chlorides came from ground water infiltration, while 45 per cent came from surface runoff. For the water years of 1952–55 ground water contributed 46 per cent of the chlorides, while 54 per cent came from flood flows. For the 6-year period 50 per cent came from each source.

That the surface water carries 50 per cent of the total mineralization at Gainesville and that the remainder comes from ground water accretion is significant. At this stage of the investigation, there can only be speculation as to the origin of dissolved solids carried by surface runoff. Some come from the dissolving of salts which have formed in the dry beds of intermittent streams. Part of these stream beds are as white during times of drought as if they were covered by new-fallen snow. Additional amounts come from the dissolving of exposed formations.

Oil brine ponds filled to overflowing are scattered throughout the oil-producing areas, and some of these are in stream channels where surface water can break the dikes and flush out the brine. Other brine ponds overflow at times of rain so that their contents,

along with that in natural sinkholes, are washed downstream. In addition, the accumulation of wastes from oil fields, salt mines, and irrigation in the alluvial material of intermittent streams is flushed out to add solids to the surface wash.

Reduction of Minerals

The author indicated some methods which can be used to reduce the dissolved solids from natural sources. Brines from oil fields can be used for flooding the oil formations with water to increase the yield of oil. Where this is not practical, the brine can be disposed of underground.

Four salt mines in the vicinity of Hutchinson, Kan., have demonstrated that the pollution from that industry is unnecessary. Until recently their wastes to the Arkansas River carried nearly 300 tons of salt per day. A program of modernization and waste-saving within the plants, conversion from using brine water for cooling, and discharging sludge to abandoned workings has eliminated this source of chloride pollution. The waste loadings from other salt mines in the two basins have not yet been evaluated. Practical methods for disposing of the large volume of residual salts from irrigation need to be developed. In the Wichita Falls area, for example, this problem is of as much interest to irrigators as to municipal water utility officials.

Much additional data on water quality in streams are needed before this

study is completed. Because a substantial amount of flow and quality information has been collected over the years by water departments, the US Geological Survey, and the states, the analysis of this problem is easier and firm conclusions can be reached at an earlier date.

Collection of the additional data which are needed should extend long enough to assure that the data are reasonably representative. If data were not available at several key points for long periods of time, there would be no possibility of completing this study with 2 years of data collection—5–10 years would be required.

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Organization of the Arkansas-White-Red Basins Inter-Agency Committee

—John A. Short—

A paper presented on Apr. 21, 1958, at the Annual Conference, Dallas, Tex., by John A. Short, River Basin Representative, US Dept. of Agriculture, Tulsa, Okla.

THE Arkansas-White-Red River Basin area constitutes about 282,000 sq mi in the southwest portion of the United States. The three major rivers and their tributaries drain approximately one-eleventh of the nation's land area, including all of Oklahoma and parts of Colorado, New Mexico, Kansas, Texas, Missouri, Arkansas, and Louisiana.

The Arkansas River rises in the Rocky Mountain area of southern Colorado and flows in an easterly direction across the plains area. The Red River rises in northeast New Mexico and flows easterly across the plains area. The White River differs from the other two major rivers in the basin in that it rises in the Ozark Mountain section of northwest Arkansas. This geographical situation gives rise to certain peculiar characteristics of the three streams and their tributaries.

The waters of the Arkansas and Red rivers which originate on the mountain slopes are almost wholly used in that area, and both rivers leave the high plains with no sustained flow. The areas immediately eastward are also unproductive of runoff. The 97th meridian, which is about the longitude of Wichita and Oklahoma City, divides the area roughly in half. Ninety per cent of the total flow from the three river basins originates east of this line.

These factors, together with the varied climatic and land conditions, combine to present almost an unlimited variety of problems in water and related land resource development.

About 7,000,000 people live in the Arkansas-White-Red basins. In 1950, 56 per cent of the total population was classified as rural. Nine cities in the area have populations exceeding 50,000. They are: Oklahoma City and Tulsa, Okla., Wichita, Kan., Shreveport, La., Little Rock, Ark., Amarillo and Wichita Falls, Tex., Springfield, Mo., and Pueblo, Colo.

Committee Background

The Arkansas-White-Red Basins Inter-Agency Committee (AWRBIAC) had its inception in the Flood Control Act of 1950. Section 205 of that act directed that a comprehensive integrated plan of improvement be developed in the Arkansas, White, and Red basins for navigation, flood control, domestic and municipal water supply, reclamation and irrigation, development and utilization of hydroelectric power, conservation of soil, forest, fish and wildlife resources, and other beneficial development and utilization of water resources, including salinity, sediment control, and pollution abatement. The act further directed that the plan be coordinated among the de-

partments of Army, Interior, and Agriculture, the Federal Power Commission, other federal agencies, and the states.

Following passage of the Flood Control Act of 1950, the President directed the federal agencies to conduct the investigations on an interagency basis. At that time, there was existing in Washington the Federal Inter-Agency River Basin Committee, commonly known as FIARBC. This committee was an informal organization of federal agencies with responsibilities in water and related land resources development.

In response to the President's letter, the FIARBC met in Washington, D.C., on Jun. 12, 1950, and passed a resolution establishing AWRBIAC, with the federal agencies participating to be the same as those on the FIARBC. The purpose of the committee was stated as being:

... to implement the policies and purposes of the Federal Inter-Agency Agreement dated Dec. 29, 1943, by providing a means through which the field representatives of the participating federal agencies may effectively interchange information and coordinate their activities among themselves and with those of the states in the investigation and preparation of report covering the water resources and related land resources of the Arkansas, White, and Red River Basins.

Initially, federal representatives were named to AWRBIAC by the departments of the Army, Interior, Agriculture, and Commerce, and by the Federal Security Agency and the Federal Power Commission. In 1953, the representative of the Federal Security Agency was redesignated as the representative of the Department of Health, Education, and Welfare. During the same year the Department of Labor was added to the membership. Prior

to the first meeting of the committee, invitations to participate in its work were extended to the governors of the eight Arkansas-White-Red states. Each governor subsequently appointed a representative to act for him on the committee and to coordinate the activities of his state. These representatives participated on an equal basis with the members representing the Federal agencies. In March 1954, the President appointed Walter L. Huber to the staff of the executive office for the purpose of serving as presidential adviser on matters pertaining to the three river basins.

Initial Study

The committee held its first meeting on Jul. 28, 1950. Throughout the survey, the committee met regularly, mostly at 1-2-month intervals. Most of the meetings were held in Tulsa, Okla., although at least two meetings were held in each participating state. Some of the meetings were open to the public and provided opportunity for residents of the area to keep informed concerning committee activities. The actions of the committee are recorded in official minutes.

In proceeding with the survey and formulation of the plan for the river basins, the interagency committee encountered a number of problems that do not ordinarily confront an individual agency in developing plans for specific functions in a more limited area. These problems arose because of several factors, including: [1] the long-range nature of the plan; [2] the enormous size of the area and its wide diversity of resources, potentialities for development, and resource problems; [3] the large number of elements requiring consideration and coordination; [4] the many different, and sometimes

competing, purposes to be served by the same resources; [5] the existence of resources plans and programs in various stages of development and operation when the survey was initiated; [6] the number of agencies, both state and federal, operating under somewhat different laws and policies that had interests and responsibilities in connection with the survey; and [7] the absence of a uniform national policy for governing resource development planning.

The committee completed its report in 1955, and it has since been published (1). The report does not attempt to set forth details of programs or projects, nor is it an authorizing document. Rather, it sets out a framework plan for the Arkansas-White-Red basins within which detailed agency plans and programs are expected to be carried out in the future. It also points out certain areas of further coordination of agency programs required as those details are worked out. The report definitely does not purport to be a rigid framework in which no modifications can be made. Instead, it repeatedly points out the necessity of periodically bringing information and plans up to date in light of current physical and economic conditions.

Reorganization

By the time the committee had finished its report in 1955, the FIARBC in Washington had been abolished. There had been established, however, a new organization with presidential approval. This organization is called the Inter-Agency Committee on Water Resources (IACWR). The membership on IACWR consists of a principal policy official, such as the secretary, under secretary, or assistant secretary of the departments represented.

Before making its report in 1955, the AWRBIAC had advised the IACWR that it anticipated dissolution as of Jun. 30, 1955. As a result of expressions of state and federal interests in the need and desirability for a continuing coordinating body in the basins, however, the IACWR on Jun. 14, 1955, approved a charter for a new AWRBIAC to be activated as soon as practicable after Jul. 1, 1955. The principal purposes of the new committee, as set forth in the charter, are: to provide, at the regional level, for improvement of coordination of activities in the field of water and related land resources and to provide means by which interagency problems in this field may be resolved; to suggest to the IACWR and to the state changes in law or policy which would promote these purposes; and to collect and interpret basic data.

The new committee held its initial meeting in Tulsa, Okla., on Sept. 15, 1955, electing the Army as chairman agency for the remainder of the year 1955-56. In view of the preparations necessary for handling the chairmanship, it was decided to elect each chairman agency a year in advance. The Department of the Interior was elected for the year 1956-57. The Department of Agriculture has served as chairman agency for the year 1957-58, and the Department of Health, Education, and Welfare will serve as chairman agency for the year 1958-59.

A subcommittee composed of the Department of Health, Education, and Welfare, chairman, the Federal Power Commission, and the states of Arkansas and Oklahoma was appointed to review the organizational structure and activities of other regional interagency committees and to recommend upon an organic and operating structure for

AWRBIAC. The subcommittee submitted its report at the Nov. 16, 1955, meeting in Tulsa, Okla., in the form of a draft of recommended bylaws for the governing of AWRBIAC. This draft, after committee discussion and modification, was adopted as the Articles of Organization and Procedure for AWRBIAC.

Objectives

Rather than devote time to the details of the articles, it is more appropriate here to cover briefly the general philosophy and objectives that went into their development. A basic objective was to lay the groundwork for an ambitious, but realistic, program to carry out the principal purposes of AWRBIAC.

A fundamental consideration was the question of emphasis in committee activities. Although it points out the broad path to be followed, the charter permits latitude in the distribution of effort among problems on three principal levels: the working level; the regional policy level; and problems of a national level as related to the Arkansas, White, and Red basins.

To use the committee as an instrument for detailed coordination of each plan and schedule was believed impracticable. Although varied conditions of the three basins bring into focus many of the national problems, a concerted effort on these matters would tend to duplicate work being done by others. Therefore, as they appeared to offer the greatest opportunity for accomplishment, matters of regional policy upon which committee members have a more direct effect were selected for primary emphasis, without, however, exclusion of the problems on the other levels.

In order to deal most effectively with the problems of regional policy, the procedures stress active participation by the committee members themselves and encourage bringing matters for discussion directly to the committee table.

Specific Provisions

In addition to the normal organizational and procedural provisions of a charter or bylaws, the articles make specific provision for such functional considerations as resolution of conflicts; methods of collecting and disseminating information; reviews and discussions of preliminary project plans and reports, construction schedules, operation, and maintenance; reviews of law and policy; and collection of basic data. The articles further provide that plans for basin development, based on the AWRBIAC report, shall be maintained as harmonious as possible with evolving circumstances.

Regular meetings, designed insofar as practicable to be of interest to the public, ordinarily are held every 2 months and normally rotate from state to state. Business meetings are called by the chairman as required. When appropriate, other federal, state, public, and private agencies are asked to participate in committee meetings and to appoint representatives to specific ad hoc committees, in order that the work of the committee may be coordinated with related work.

There are some significant provisions in the Articles of Organization and Procedure of AWRBIAC that are worthy of note. One of these concerns the method of doing business. All actions of the committee, except where specifically exempted, are in accordance with the majority vote of the membership present. The member-

ship constitutes representatives of seven federal agencies and eight states; a quorum, however, consists of two-thirds of the membership with at least four states and four federal agencies represented.

Another significant provision is that AWRBIAC has only one standing committee—the administrative committee—and works through ad hoc committees in dealing with special problems. Ad hoc committees consist of member representatives or their designees having an interest in the subject to be considered, and the chairman thereof usually is a representative of the AWRBIAC agency having primary responsibility for the subject.

The administrative committee is responsible for formulation of meeting agenda; selection of meeting sites; summarization, when necessary, of program material, reports, or papers; supervision of meeting information and public participation and other aspects of public relations; preparation of specifications for the annual progress report; and such other duties as are prescribed by AWRBIAC. The administrative committee consists of five members: the secretary of AWRBIAC, who is chairman; two other federal representatives; and two state representatives. The next incoming chair-

man agency of AWRBIAC is one of the two federal members. The other federal member is selected from the remaining federal agencies through majority vote of those agencies in caucus. Each has a 1-year appointment. The state members are selected by a majority vote of the state representatives in caucus. Each state member is named to a 2-year term, one new member being selected each year. AWRBIAC representatives or alternates may sit with the administrative committee in work sessions, and the committee may invite others when necessary; only administrative committee members, however, may vote in committee proceedings.

Conclusion

AWRBIAC has operated under the present charter and procedures for almost 3 years. The author believes that progress is being made and that a start toward the objectives for which the committee was established has been achieved. The committee is continuously seeking to improve its procedures, however, in order that it may more effectively and more efficiently perform its duties.

Reference

1. Senate Document No. 13, 85th Congress, 1st session (1955).

Improvement of Water Quality in Kansas

Dwight F. Metzler

A paper presented on Mar. 12, 1958, at the Kansas Section Meeting, Salina, Kan., by Dwight F. Metzler, Chief Engr., Kansas State Board of Health, Topeka, Kan.

WATER quality received more public attention in Kansas in 1957 than in any previous year. During this year, progress was made in municipal and industrial waste treatment, in the abatement of pollution by oil field brine, in a study of surface water quality, and in an investigation of water quality in the Arkansas River basin.

It has come to be expected that Kansas will be a leader in the treatment of municipal and industrial wastes. In the 10-year period 1948-57, 209 municipal sewage treatment plants were constructed. The first 100 plants took more than 6 years to build; the remainder were completed in the next 4 years.

The rate of completion of sewage treatment plant projects gradually increased to a peak in 1956. The same rate of construction would probably have prevailed in 1957 if the federal grant program had not been initiated. When the act creating the program was passed in July 1956, new contract lettings were virtually stopped until procedures for processing grant applications could be arranged. The board of health announced priority ratings in December 1956.

The construction schedule is fast becoming correlated with federal grants. In December 1956, the board of health certified grant priorities for seventeen

projects and, in the following months, nine projects were begun without a grant. In July 1957, the board certified eleven projects, and it appears that five more nongrant projects will be begun by the end of the fiscal year. Three of the five communities involved, however, have indicated their intention of applying for a "pick up" from federal aid funds if they are available for the fiscal year 1959.

Final inspections have been made on five new sewage treatment plants since Jan. 1, and 27 more are under construction. Plans are completed for new plants at Clyde, Coffeyville, Englewood, Herndon, Hutchinson, and Topeka Township, as well as for plant enlargements at Ogden which built a new plant in 1952. Plans are being prepared for new plants at Andover, Burlington, Cheney, Grenola, Hiawatha, Moscow, Mulvane, and Walton. In addition, Newton, which completed a new plant in 1951, is preparing plans for plant enlargement. Engineering studies have been completed and a report submitted for new sewage treatment plants at Atchison, Cimarron, Erie, Holton, Kansas City, Larned, Leavenworth, Pratt, and Rozel. Of this group, Holton causes periodic gross pollution of its small receiving stream. Atchison, Leavenworth, and Kansas City are faced with large projects as they, together with cities in

four other lower Missouri River states, do their part in the program to reduce pollution along the Missouri River. Augusta, Kinsley, and Lenexa have engineering studies under way for enlarging facilities or building new ones.

Municipal sewage treatment during the past year has shown distinct trends. A number of small communities have built waste stabilization ponds and it is expected that, for small communities having a favorable location, activity in this direction will continue. Treating municipal waste in these ponds remains a question of some concern because half the wastes or more may originate in meat- or milk-processing plants. The single largest problem is one that was anticipated—that of keeping sufficient water in the ponds to allow treatment. The control of seepage is the big problem and some communities have been pumping large volumes of fresh water to the ponds in an effort to maintain the water level.

Dike maintenance and weed control have proved to be essential and there seems to be some trend in design toward more recirculation and somewhat higher trickling-filter loadings. The movement toward two-stage digestion was established several years ago and continues. More communities are hauling liquid digested sludge and the problem of ground garbage continues to increase—with 1957 being the worst year to date.

Three plants are now heating digesters with live steam. The process, which has some merit, raises a number of complex and still unanswered questions. Snails in trickling filters constitute a growing problem.

The salt plant at Lyons and the three at Hutchinson have made major improvements in reducing the chlorides in their wastes. Process improvements

and changes in sources of cooling water have already substantially reduced the wastes going to the stream, and nearly all of the 190 tons per day of chloride originally wasted by these industries will have been eliminated from the waste streams or placed in abandoned workings by Jul. 1, 1958.

Oil Brine Pollution Abatement

The disposal of salt brine by the oil industry is still one of the major problems in maintaining good water quality in Kansas. Because of the excellent cooperation from the industry, the state board of health has been able to report for the past several years that more than 95 per cent of all oil field brine produced in Kansas was safely handled. The 1957 legislature concluded that this was not enough and strengthened the laws relating to oil field brines in order to give more protection to surface water by elimination of seeping ponds and installation of adequate amounts of surface pipe in oil wells.

The oil industry's reaction to this has been mixed. Many producers said that the standards set forth in the new laws are no more severe than those specified in the past. Others held that these new laws would drive them out of business. There seems to be little doubt that a few drilling contractors and oil companies stopped exploration for a time after the new law was passed. Careful study of the law and several meetings with the board of health overcame most of the industry's fears.

The statute requiring a permit for all ponds set a deadline of Jan. 1, 1958, for the issuance of permits. Most of the operators waited until late December to submit applications and many more submitted them in January and February. At the end of February,

2,003 applications had been received and processed. Of these, 1,095 were approved because the ponds were so constructed that seepage would not occur—at least not sufficiently to pose any hazards to the fresh water; 265 applications—13.2 per cent—were denied and 643 provisional applications were issued for limited periods. The purpose of the provisional approval is to allow the operators sufficient time to convert to an accepted method of brine disposal. Most of those receiving the provisional approval submitted plans for abandoning leaking ponds and constructing adequate brine disposal systems.

Oil well operators in Kansas had maintained a high rate of brine disposal system construction for the past several years, with each year showing an increase over the last. December 1957 tied the previous high month for the number of new systems, and this amount was almost doubled in both January and February 1958. The cost of the disposal systems being built is \$2,000,000 per month.

Many feared that the new pond law would permanently reduce exploration for oil in Kansas and hasten the abandonment of marginal leases. A comparison of the 6 months beginning Jul. 1, 1956, with the same period a year later shows that more oil wells were completed in 1957 than in 1956. This has occurred despite an unfavorable market for crude oil. Kansas is one of the ten oil-producing states showing an increase in drilling this year over last, with twenty states showing a decline.

As far as is known, during the past year, only one municipal water supply—that at Jennings—has been affected by oil field pollution. Some

private supplies at Neosho Falls were contaminated.

Data indicate that 4,360,000 bbl of brine are being produced in Kansas daily. Of this, 41,700 bbl were going into ponds on Oct. 1, 1957. The program for licensing ponds has reduced this substantially.

Storage and Water Quality

The effect of storage and flow regulation upon water quality is of prime concern to the 140,000 persons who depend upon the Kansas River for drinking water, as well as those with similar dependence on the Neosho and Verdigris rivers. Studies along the main channel of the Missouri River show that reservoir storage and flow regulation have greatly reduced the turbidity downstream below the Garrison, Fort Randall, and Gavin's Point reservoirs. These reductions in turbidity have been significant even as far as Kansas City, 550 mi below the lowest reservoir, and have permitted an increased growth of algae. In 1953-54, taste and odor problems began to occur which required changes in treatment with activated carbon and higher chlorine dosages. Plankton concentrations increased with the clear water until they reached the nuisance level at Yankton, S.D., in 1953. Benthic algal growths became prominent the same year.

Reservoir storage—and Kansas is just beginning to see its start—seems to reduce alkalinity and total hardness as well as turbidity. Similar changes can probably be anticipated from large reservoir storage projects on other Kansas streams.

In a paper presented before the Missouri basin interagency committee at Ottawa on Nov. 20, 1957, Paul Berg

of the Bureau of Reclamation predicted that dry weather flows in the Kansas River will be decreased even though the bureau proposes to build 28 large reservoirs. Although the flow at Wamego has been less than 500 cfs for less than 2 per cent of the time, it will drop below this value 20 per cent of the time when the reservoirs are completed and 360,000 acres are irrigated.

The water quality problems caused by such a development are major because: [1] irrigation will occur during the summer season when the stream flows are usually below normal; [2] the water to be stored for irrigation is from those areas which yield low-mineral water and will not be available to dilute the waters carrying greater amounts of mineral solids; [3] the return flow from irrigated areas will carry more dissolved salts and therefore will be less useful for dilution, and [4] the minimum flows will not be available to maintain reasonable chemical quality and to carry away treated wastes.

The problem of supplemental irrigation in the eastern half of Kansas will grow. Municipal officials whose cities are dependent upon surface water will have to maintain a careful scrutiny of proposed upstream irrigation developments if they are going to continue to protect the quality of their water supply.

An example of the effect of such a program can be observed in the Blue and Republican rivers which provide the high quality water for dilution of the more highly mineralized flow from the Smoky Hill River. If supplemental irrigation is encouraged, there will be times when no dilution is provided by either of these streams. In fact, the return flow from the irrigated lands

may actually increase the mineralization of water in the Smoky Hill. If this were to happen, the effect upon municipal and industrial growth along the main channel of the Kansas River would be considerable.

Surface Water Quality Study

The chemical quality of surface waters in Kansas was investigated by the Kansas Water Survey—a part of the University of Kansas—in the 1890's and early 1900's. The work of Bailey and Hoad was pioneering in nature and provided invaluable data about the potentials of some Kansas streams for oil development or other industrial activities. Since 1907, periodic chemical analyses have been made of municipal water supplies from both surface and ground sources. This information, supplemented by special stream pollution studies, has provided the primary background of information on surface water quality in Kansas.

The search for additional sources of water by cities and industries during the recent drought revealed the value of existing records of chemical quality and emphasized the need for collecting and distributing more data of this kind.

To place this basic data collection program on a regular and systematic basis, the board of health, in 1956, established 34 regular sampling stations on the major streams of the state. Water samples are collected monthly and complete chemical analyses made in the water and sewage laboratory. Many of the samples are collected by local water utility officials who are, thereby, making a major contribution to this program. Wherever possible, the sampling stations are located at or near gaging stations so as to determine any relationships which may exist be-

tween stream flow and chemical quality. A full year's record has now been accumulated at these 34 stations and a tabulation of the chemical analyses is being prepared for distribution to interested persons. It is planned to publish the data annually. Four new sampling points have been added to the network in 1958.

In addition to this new information, all the known existing information on the chemical quality of surface waters of Kansas is being compiled on a major river basin basis. The first project has been completed with the publication of a booklet with data for the Marais des Cygnes Basin for the period 1899-1957. From the Marais des Cygnes report it can be concluded that the surface waters of this basin are of fine quality and, with adequate protection from pollution, will remain usable at all locations.

Arkansas River Basin

The principal unsolved pollution problem in the Red and Arkansas river basins is caused by inorganic pollution from both natural and man-made sources. Here, more than in most river basins, there is a large variation in rainfall, soluble mineral deposits are exposed to leaching and solution action, flash floods occur, the streams are intermittent, and great underground reservoirs of oil and salt water are pumped to the surface and sometimes spilled.

The USPHS water quality study undertaken in these river basins is important to Kansas water supply personnel for two reasons: It holds the hope of developing methods to improve the quality of water in the Arkansas and Ninnescah rivers in Kansas, and it provides some basis for compact negotiations between Kansas and Oklahoma, the legislatures of which have agreed to make a compact dividing the waters which flow from Kansas into Oklahoma. This is of real interest and concern to those who depend upon the Neosho or Verdigris rivers as a source of supply. These two rivers supply most of the good quality water to the lower Arkansas River which is stimulating the great industrial development in the vicinity of Muskogee, Okla.

The Kansas State Board of Health is cooperating in the USPHS project, and data for the study have been supplied by several city water departments in Kansas. The data already collected show that at times of medium to high flow, there are large volumes of good quality water available in streams which are mineralized at low flow. Future studies will be aimed at pinpointing the sources of natural pollution and determining what measures can be taken to reduce them. If Congress approves and if the USPHS is able to staff the project, it is expected to be completed in 3 years.

Effects of Missouri River Basin Control on Water Quality

Panel Discussion

A panel discussion presented on Apr. 21, 1958, at the Annual Conference, Dallas, Tex.

Introduction—Melvin P. Hatcher

A paper presented by Melvin P. Hatcher, Director, Water Dept., Kansas City, Mo.

THE project now generally referred to as the Pick-Sloan plan for the development of flood control, navigation, irrigation, and power production in the Missouri River Basin is now more than 13 years old. Before the adoption of this unified plan, there had been two plans of approximately the same nature. One had been developed by the US Corps of Engineers, and dealt mainly with flood control and navigation. The other was developed by the Bureau of Reclamation; it was primarily concerned with irrigation. The overlapping of these two plans pointed to the great need for unification, which was accomplished in 1944 with the aid of participants from the affected states. The compromise plan was named for Lewis A. Pick, brigadier general, US Army, who sponsored the Engineer Corps plan and for W. G. Sloan, assistant regional director of the Bureau of Reclamation, in charge of the bureau's work. Congress gave its approval to start on the plan in December 1944. The watershed of the Missouri River and its tributaries and the location of the main-stem reservoirs are shown in Fig. 1.

Although this panel discussion considers primarily the effect of main-stem dams on municipal water supplies, figures on the total scope of the Pick-Sloan plan are of interest. The plan deals with a land area of 529,000 sq mi, comprising one-sixth of the continental United States. The present total estimated cost of the plan is 5.6 billion dollars. About 50 per cent of the individual projects in the plan are complete or under construction.

Concerning the status of the program for main-stem dams and reservoirs, the ultimate plans call for six dams. Four

TABLE 1
Main-Stem Dams on the Missouri River

Dam	Capacity 1,000 acre-ft	Completion Date
Fort Peck	19,412	1938
Garrison	23,000	1957
Oahe*	23,600	1962
Fort Randall	6,300	1956
Big Bend†	340	—
Gavin's Point	540	1957
Total	73,192	

* Under construction.

† Construction yet to begin.

have been completed and are in use. A fifth is under construction, and no start has been made on the sixth. Proceeding downstream from Fort Peck in Montana, all main-stem dams are listed with their reservoir capacities and their completion dates in Table 1.

Gavin's Point Dam is about 215 river miles upstream from Omaha, 469 mi

reservoirs has been controlled on the basis of a yearly projection. This schedule for releases from dams is compiled each year by the Coordinating Committee on Missouri River Main-Stem Reservoir Operations. The committee is made up of representatives of the several interested federal agencies and by state engineers representing the

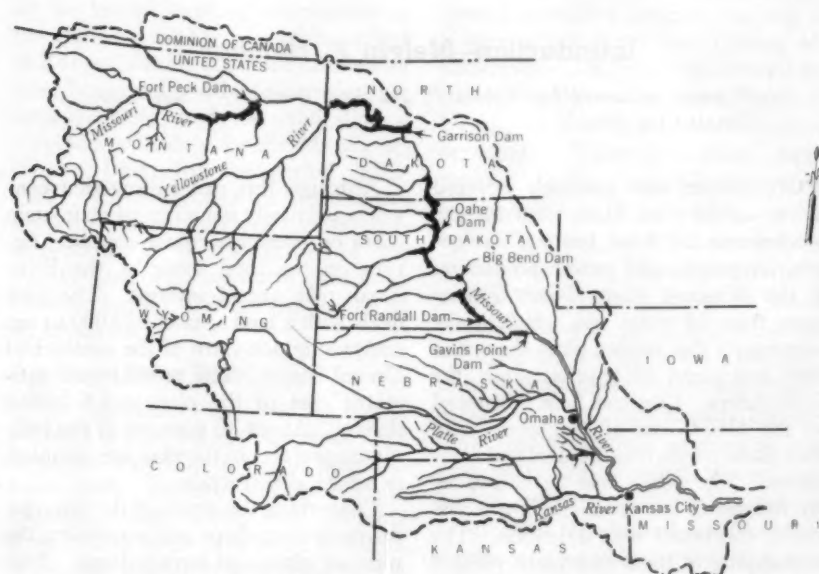


Fig. 1. Missouri River Basin

Locations are shown for completed and projected main-stem dams and reservoirs.

from Kansas City, and 840 mi from St. Louis. Water travel time in the river to Omaha is about 3 days, to Kansas City about 7 days, and to St. Louis about 11 days.

Control of Flow

Beginning in 1953 and continuing through subsequent years, the flow of water through the system of main-stem

seven states most affected by river flow plans.

The committee seeks a compromise of all of the needs for water and for reservoir storage space. It seeks to conserve reservoir capacity for the snow runoff so as to insure against floods. It aims to provide flows from mid-April to mid-November that will support navigation from Sioux City,

Iowa, to the mouth of the river. It aims to hold winter flows to the minimum needed for public water supply. For the most part, the need for water for power generation is made subsidiary to the other three needs.

Water supply to the cities below the Gavin's Point Dam is affected most by the winter operations. In recent years the winter flows of the Missouri River have shown a steady year-by-year increase in the concentration of organic wastes that contribute to taste and odor. Likewise, the bacterial load has

flows for the immediate future years. It seems likely that there will be need for very careful attention to these minimum flows in the years that are immediately ahead.

Hardness and Turbidity

In 1946, Lewis A. Pick stated in the *JOURNAL (1)* that the system of reservoirs on the main stem would "be of great assistance to the water works engineers in river cities." This author wondered at the time, without having the data for an estimate, whether the evaporation off reservoir surfaces might not add to the concentration of minerals. That effect has not been predominant. The average mineral content is affected more by the fact that melted snows are not now forever lost in the spring runoff.

The reduction in hardness, mostly noncarbonated hardness, results in a saving of lime and soda ash at the Kansas City plant that is worth \$84,000 per year at the present time. Likewise, there has been a helpful reduction in the turbidity. It is difficult to assign a dollar value to this reduction, but it does have some value.

Although the bacterial load has increased in the 13 years since the beginning of the Pick-Sloan plan, there appears to be little reason to credit or charge the reservoir system with any effect on this bacterial load.

Reference

1. PICK, L. A. The Missouri River Development Program. *Jour. AWWA*, 38:859 (Jul. 1946).

TABLE 2
*Minimum Flow Requirements at
Missouri River Cities*

Period	Flow—cfs		
	Sioux City	Omaha	Kansas City
Jun.—Sep.	6,100	8,500	12,700
Apr.—May and Oct.—Nov.	2,700	3,800	5,700
Dec.—Mar.	3,700	5,100	7,600

shown a similar trend. A certain volume of water is needed if these concentrations are to be kept within limits that will insure a reasonably satisfactory water plant product. In 1952 the minimum requirements were fixed with the help of the US Public Health Service, as shown in Table 2.

At the April 1956 meeting of the coordinating committee, Missouri and USPHS representatives recommended an increase of 2,000 cfs in the minimum

Reservoir Influences on Central Missouri River

—Joe K. Neel—

A paper presented by Joe K. Neel, Biologist, Water Supply & Water Pollution Control Activities, USPHS, Kansas City, Mo.

Prior to 1952, the central Missouri River (from Williston, N.D., to Omaha, Neb.) was very turbid during absence of an ice cover. Problems encountered in water treatment for municipal use were seldom biological in nature. A plankton reconnaissance made by the US Public Health Service in 1950 (1) and a study of the lower Missouri completed in 1945 (2) both revealed very low concentrations of taste- and odor-producing organisms and led to the belief that development of such algae was largely inhibited by excessive turbidity.

Completion of the reservoir system entailed in the Corps of Engineers' Missouri River Developmental Plan was expected substantially to reduce turbidity over long river reaches; and state health authorities and water utility officials expressed concern over the probability of taste and odor problems developing from algal growths in the clarified river. The engineering section of the Missouri Basin Health Council, composed of the chief sanitary engineers of the ten Missouri Basin states, recommended in February 1952 that the USPHS thoroughly investigate this matter, as the various states represented were of the opinion that they could not individually give it proper consideration. The USPHS outlined investigational procedures to evaluate the situation and notified the division engineer of the Missouri River Division, Corps of Engineers, of potential troublesome developments, the concern of state and municipal officials, actions taken to date, and required finan-

cial support. The Corps of Engineers showed immediate interest in the problem and, in May 1952, agreed to furnish major financial support for a study to be directed by the USPHS.

Procedures and arrangements made for prosecution of the study have been described in progress reports (3-5) and will also appear in a final comprehensive report embracing the entire activity. It seems unnecessary, therefore, to go into detail on those phases in this article. The study was made possible through the wholehearted cooperation of local water plants and state health agencies in collection of samples and performance of certain analyses. All water plants from Williston to Council Bluffs cooperated in the routine program, and all plants drawing from the Missouri River between Williston and the river's mouth contributed analysis data and other information. Corps of Engineers contributions were not limited to financial support. They also provided major assistance to sampling and analysis programs and report reproduction, as well as furnishing information on sediment loads and reservoir operation.

The investigation began in August 1952 and proceeded in an intensive fashion until July 1957. Since then a general surveillance has been maintained over the region most affected by the reservoir system. Discontinuance of the intensive program was recommended, because the influences of reservoir filling and relatively low elevations therein were well-known in 1957, and economics indicated a halt in this type

of activity until all closures were effected and anticipated operational levels attained. At that time intensity study will be reinitiated. Data discussed here largely cover the period 1952–56.

Reservoirs

This article is concerned with the effects of four operational main-stem reservoirs (Fig. 1). The oldest impoundment, Fort Peck Reservoir, dates

date of completion. After closure, some control of discharge is usually possible. Three of these reservoirs—Fort Peck (maximum capacity 19,400,000 acre-ft), Garrison (maximum capacity 24,500,000 acre-ft) and Oahe (maximum capacity 23,600,000 acre-ft)—will be huge bodies of water when operational levels are attained. Fort Randall (maximum capacity 6,300,000 acre-ft) is a large reservoir, and Gavins Point (maximum capacity

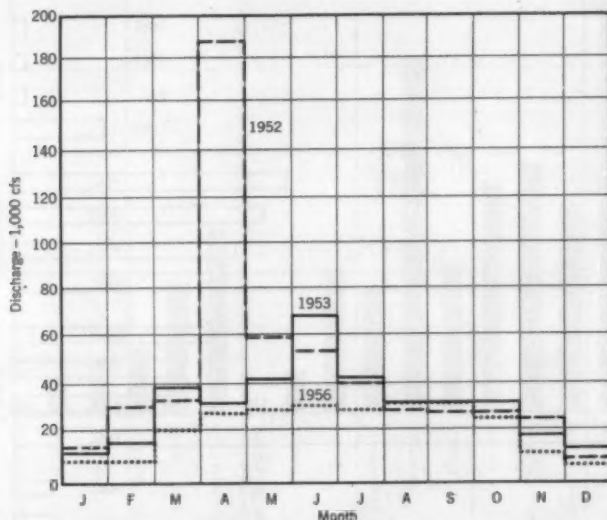


Fig. 2. Mean Monthly River Discharges at Omaha, Neb.

Discharge figures are plotted for 1952, 1953, and 1956, as indicated. Discharge for 1956 reflects the influence of control by Fort Randall and Gavins Point reservoirs.

back to 1938; Fort Randall Dam was closed in August 1952; and closures of Garrison and Gavins Point dams were effected in December 1953 and August 1955, respectively. Oahe Dam, which will form the fifth reservoir in this region, is scheduled for closure this year. Closure refers to the date that the river is put through discharge openings in the dam, not the

540,000 acre-ft) is a small unit in this system. All reservoirs are multipurpose in function, with flood control and power production having greatest development at this time. River navigation is sustained by special releases from March to November.

Discharge

General reservoir effects upon discharge are clearly indicated by annual

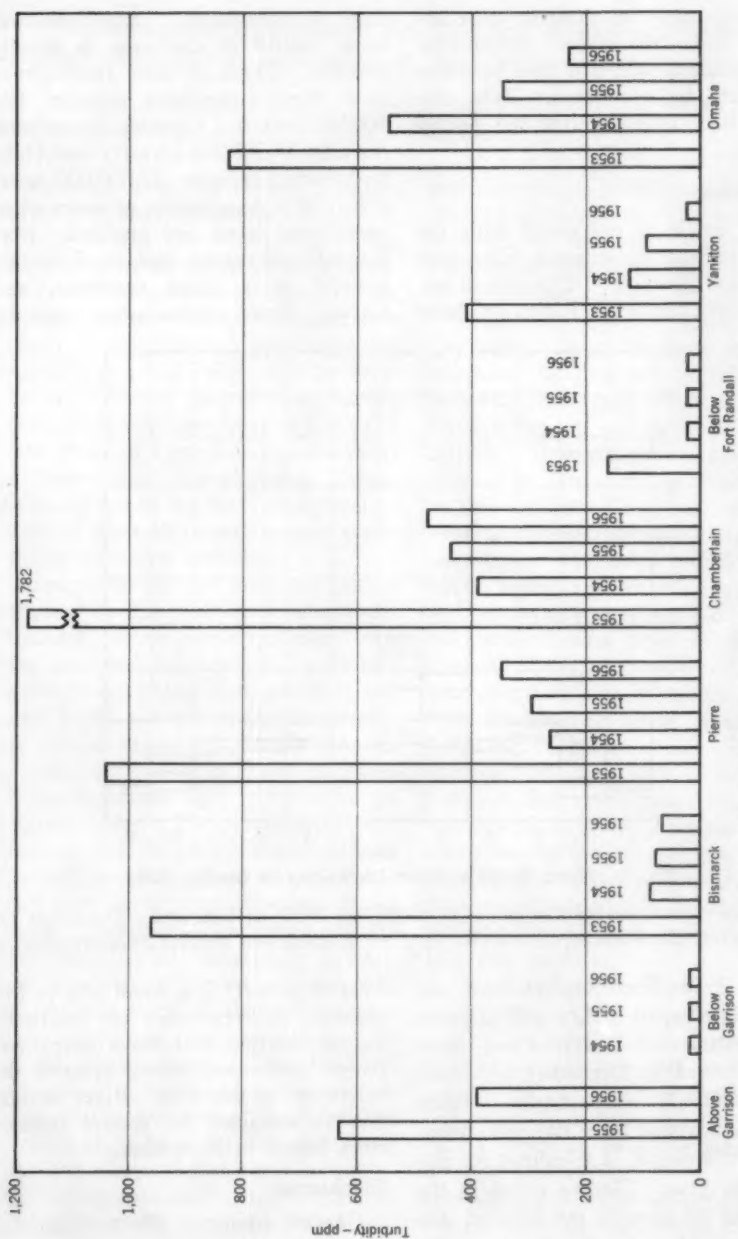


Fig. 3. Average Annual Missouri River Turbidities, 1953-56

Bars show average turbidities for individual years, as labeled, at various points along the river.

patterns at Omaha (Fig. 2) before and after upstream impoundment. The river normally exhibited two high stages each year—one in early spring from snow melt over the prairies in the central basin, and another in June developing from mountain snow melt and general rains over the prairie region. The spring rise in 1952 developed into a severe flood that inundated many

to coincide with recession of high stages in July. Thereafter, control of discharge at Omaha was vested in Fort Randall Reservoir, with Gavins Point serving as a regulating body since 1955. A typical pattern of reservoir control is shown for 1956 in Fig. 2. Releases were increased for navigation in the spring, maintained at a uniform rate for about 7 months, and then dropped

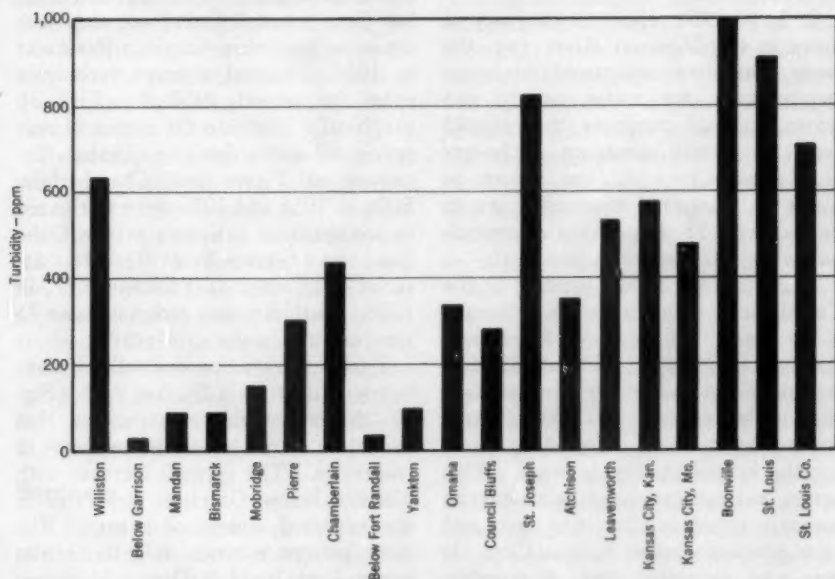


Fig. 4. Average Missouri River Turbidities for 1955

These bars indicate the turbidity for one year (1955) throughout the entire length of the river below Williston, N.D.

river towns (Omaha was saved by last-minute elevation of flood walls), and above normal discharges continued through June. In 1953 the spring rise was comparatively insignificant, but the June rise was sharp and distinct. In 1952 and 1953, navigational levels were maintained by increased releases from Fort Peck Reservoir that were timed

to winter levels that are maintained largely for water supply and waste disposal purposes. Provision of flows for these purposes is in accordance with the following actions of committees concerned with river control:

1. On Mar. 23, 1950, the Missouri Basin Inter-Agency Committee passed a resolution stating that in review of

project construction and operation plans and in any action taken by the committee in respect to such plans, it shall always be its policy in the interest of public health and welfare to protect and to recognize the necessity of making available adequate quantities of water for present and potential requirements for domestic, municipal, sanitation, and sewage purposes east of the 98th meridian.

2. In its 1951 report on adequacy of flows in the Missouri River (6), the same committee designated minimum requirements for water supply and waste disposal purposes that should result in certain minimum discharges at Kansas City, Mo., as shown in Table 2. Required discharges are to be decreased 25-40 per cent as municipal sewage treatment is provided.

3. At the April 1956 meeting of the Coordinating Committee on Missouri River Main-Stem Reservoir Operation, the state of Missouri and the USPHS recommended that winter flows at Kansas City be kept at least 2,000 cfs above the minimum levels referred to above for the immediate future years. This action was recommended as an interim measure to aid in alleviating taste and odor problems below Kansas City. It was also requested that, if possible, Gavins Point releases be increased just prior to potential freeze-ups in order to compensate for sudden flow losses.

Turbidity

Despite its traditional appearance of being "too thick to drink and too thin to plow," the Missouri River did not carry a particularly heavy suspended sediment load in terms of dry weight per volume. During the period 1937-48, the usual load in this river reach was less than 1 per cent of the total volume. High turbidities were

due to small, light, flattened clay particles that effectively reflected light, yet contributed a small overall sediment load.

In 1952, and in 1953 before Fort Randall Reservoir operation was effective, turbidity varied directly with discharge within the limits of flows occurring between August 1952 and July 1953. Thereafter, normal turbidity-discharge relationships disappeared below Fort Randall Dam; and they met the same fate below Garrison Reservoir in 1954. Annual average turbidities over the period 1953-56 (Fig. 3) graphically illustrate the extent of reservoir influences down to Omaha. Increases at Pierre and Chamberlain, S.D., in 1955 and 1956 were attributed to construction activities at the Oahe Dam site. Gavins Point Reservoir assured clear water at Yankton, S.D., in 1956. Turbidity was reduced about 75 per cent at Omaha in 3 years.

Turbidity variation over all the river below Williston, N.D., for 1955 (Fig. 4) shows several irregularities that cannot be attributed to the presence of reservoirs. The general increase with distance below Garrison Reservoir is the expected course of events. The same pattern extends only to Omaha below Fort Randall Dam. Variation below that point reflects, among other things, varying degrees of total river representation by the several plant intakes. Omaha, for instance, draws from the main path of flow, but Council Bluffs, just 7 mi downstream, takes water from a much slower current near the opposite shore. Kansas City, Kan., and Kansas City, Mo., intakes are located on right and left banks, respectively; and the St. Louis city and county intakes are but 0.6 mi apart on the same shore. It appears that few intakes in the lower river truly show

general river conditions. Not all variation can be attributed to location, however, as local tendencies either to pick up or deposit particulate matter are also indicated by sediment data from representative cross-sectional samples.

Turbidity reductions by this reservoir system have extended to the mouth of the river. Annual averages from 1926 to 1955 at Kansas City, Kan., show the first sharp decrease in 1953. This pattern is duplicated at the St. Louis city and county intakes, with very similar concentrations for each of the 3 years following impoundment at Fort Randall.

Relationship of turbidity to annual sediment loads in various reaches shows that the former is a reliable measure of variation in suspended matter. Changes in sediment load along the lower river show the existence of a tendency for sediment to deposit and erode at different locations. They indicate that maximum loads or turbidities are caused by local conditions and are not always indicative of the river's discharged sediment load.

Hardness

It is not the purpose of this article to discuss all chemical phenomena that have been associated with reservoir impoundment and operation. Inasmuch as a number of reservoir influences concerned dissolved-mineral content, the author believes that reference to observed hardness variation will serve to indicate the general nature of some conditions leading to chemical change. Events occurring in new reservoirs tend either to increase or decrease hardness concentration. If no change occurs in impounded water, the belief is that augmentation and depletion factors exactly balance each other. Decreases arise either through storage of lowly

mineralized surface runoff, that serves to dilute on an annual basis all water caught in reservoirs, or by deposition. Deposition is most often occasioned by photosynthesis of algae and other aquatic plants and the results from their ability to convert soluble calcium or magnesium bicarbonate into weakly soluble carbonate that is lost from solution. Hardness increases are caused by leaching of minerals from previously uninundated soils; by thermal and chemical stratifications that enhance hardness buildup in the deeper waters that are ultimately discharged through penstocks and other types of bottom outlets; and, on rare occasions, by rapid evaporation of surface waters. The last process has been of no measurable significance to date in the Missouri River main-stem system.

Annual average hardness concentrations at significant stations over the period 1953-56 appear in Fig. 5 as percentages of the concentration above the reservoir system, which is designated as 100. In 1953, Fort Randall effected a reduction that carried all the way to Omaha. In 1954, Garrison Reservoir reduced hardness down to Chamberlain; and Fort Randall induced a decrease that again carried to Omaha. In 1955, hardness increased in Garrison Reservoir, and this buildup was responsible for higher levels at all downstream stations, although Fort Randall again reduced the concentration in its impounded waters. In 1956, Garrison showed only a slight increase, yet downstream levels remained high. Reduction effected in Fort Randall Reservoir was insufficient to reduce concentration to the level it exhibited before entering Garrison Reservoir. These events illustrate the individuality of reservoirs and their unreliability during early stages of impoundment.

Through 1956, prolonged stratification had not occurred in either reservoir.

Phytoplankton

Algae began active growth in the reservoirs and river soon after clarification occurred. Previously, the main-stem algae population appeared to consist of only those forms that had the ability to survive the turbid situation when introduced from a tributary. Attached filamentous forms, previously ab-

1954, algae posed no problem in or below Garrison Reservoir but again developed to a nuisance level at Yankton. Fort Randall Reservoir produced as heavy a crop as the river that year. In 1955, production rose in Garrison and declined in and below Fort Randall whose productivity, however, was still above that of Garrison. The lower reservoir extended up to Chamberlain upon several occasions, a fact reflected in greater algal growth at this station.

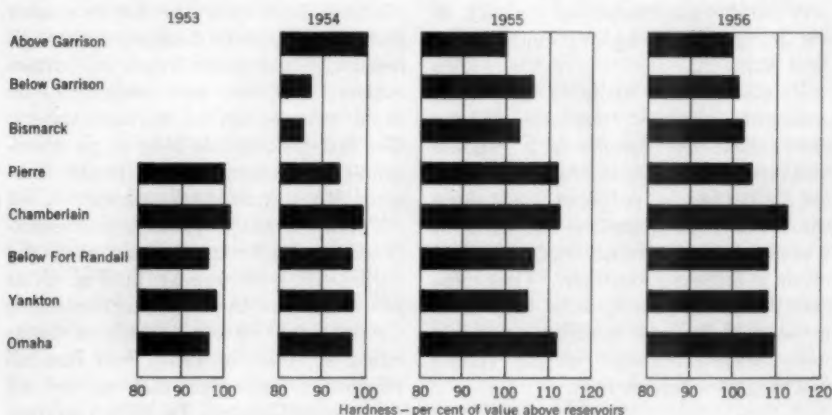


Fig. 5. Variations in Missouri River Hardness

Bars are plotted as percentages of hardness as compared to average values (designated as 100) above the midriver reservoirs (measured at Pierre, S.D., in 1953 and above Garrison Reservoir during 1954-56).

sent, became a common sight in 1953 on submerged timber and brushwood in clarified stretches of the river.

Phytoplankton densities indicated as percentage of annual average density above the reservoir system, again shown as 100 per cent, appear in Fig. 6. In 1954, these algae grew better in the river below Fort Randall Dam than in the reservoir itself, and occasioned taste and odor problems at Yankton, S.D., in late summer and early fall. In

Algae exhibited their greatest development of the first four postimpoundment years in Fort Randall Reservoir in 1956. Densities in and above Garrison Reservoir were greater than during previous years, but levels there appeared relatively insignificant considering the concentration developed in Fort Randall. Algae concentrations in the nuisance range extended downstream to Omaha in 1954, 1955, and 1956.

To date no main-stem reservoir has developed conditions leading to discharge of oxygenless or oxygen-poor water. Air ducts to the flood discharge tunnels in the Garrison and Fort Randall dams have, as such releases were made, resulted in supersaturated oxygen concentration for a few miles below each dam. Photosynthesis by algae has raised oxygen content above the saturation level in reservoirs and over long river reaches.

Bismarck, N.D., in 1955 and 1956; at Chamberlain, S.D., in 1955 and 1956; and at Council Bluffs, Iowa, in the winters of 1955-56 and 1956-57.

Most operators report lesser use of coagulants in line with turbidity reductions, and those practicing hardness removal indicate easier operation and the use of less chemicals. Reduction in amount of chemicals required has developed from lower or more uniform river concentration. Often it is difficult

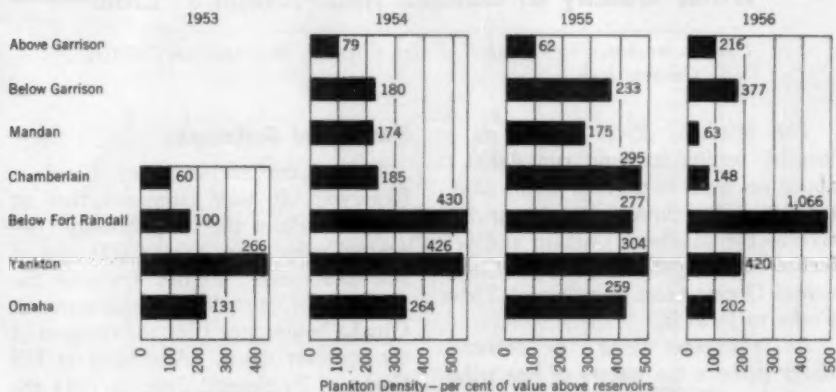


Fig. 6. Variations in Missouri River Phytoplankton Density

As in Fig. 5, figures are based on percentages of the average density in plankton above the reservoirs (measured at Chamberlain, S.D., in 1953 and above Garrison Reservoir during 1954-56). Figures at the end of each bar are the average annual densities, measured as number of plankton per milliliter.

Greater reservoir depths may some day result in thermal and chemical stratification that will place oxygenless water at flood control and penstock discharge levels. It appears that this phenomenon is less likely at Fort Randall and Gavins Point than in the more upstream reservoirs.

Effects on Treatment

Plankton algae caused problems in water treatment at Yankton in 1953, 1954, 1955, and 1956; at Mandan and

to determine exact benefits or damages, as water plant processes or operators have changed. At one location, change in operators resulted in increased use of softening chemicals, although the average hardness concentration in the river was then the lowest on record.

With the exception of taste and odor problems and excessive water level fluctuation immediately below Gavins Point Dam, operators believe that the river and water treatment have bene-

fited from changes wrought by the development program.

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—Water Quality at Omaha, Neb.—Joseph F. Erdei—

A paper presented by Joseph F. Erdei, Chemist, Metropolitan Utilities Dist., Omaha, Neb.

The Missouri River (2,550 mi in length) begins its long run 4,000 ft above sea level in a green fertile Montana valley; three clear, sparkling rivers—the Madison, Gallatin and Jefferson—flowing down from the Continental Divide come together at Three Forks to form it.

As it sweeps along, the Missouri River gathers the waters of one tributary after another. Until it reaches the Yellowstone River, the Missouri's water runs clear. Fort Peck's 4-mi long dam (1937) forms a wide, blue lake. Near the North Dakota border, the Yellowstone River dumps silt from the dry, brown plains of Wyoming and Montana into the Missouri River. From that point on, as it receives the waters of other tributaries, the river grows increasingly muddy. Some of this silt is impounded behind the other mammoth dams. By 1980, the government engineers will have built 138 major power, irrigation, and flood control projects in the Missouri Basin. Some of the silt piles up in sand bars, but most of it is now being impounded behind the five huge dams.

Suspended Sediment

Before the enclosure of Garrison Reservoir, it was estimated that at Missouri Point the "Big Muddy" deposited more than 200,000,000 tons of soil each year. Figure 7 shows the amount of suspended sediment at Omaha before and after the closures of the up-river dams. According to US Corps of Engineers' data, in 1944 the Missouri River passing Omaha had approximately 251,700,000 tons of suspended sediment load; in 1951, approximately 219,500,000 tons; in 1952, 157,900,000 tons; in 1953, 80,500,000 tons; and in 1954, approximately 37,300,000 tons.

Of the total suspended load passing Omaha, sand represented almost one-half in 1956, whereas in previous years it was one-fourth or less of the total. Omaha plant records show a tremendous drop of total suspended solids between 1950 and 1956 as calculated in tons per million gallons of water pumped into the treatment plant.

The construction of the dams on the main stem, and smaller structures on important tributaries will do much to

reduce the silt and clay load. It is predicted that upon completion of the program, the Missouri River will be a relatively clear stream over its lower reaches.

Turbidity and Hardness

Omaha personnel are very interested in turbidity, as they are clarifying only the Missouri River water. In Fig. 8, the yearly average definitely shows a consistent, marked downward trend,

quality result at Omaha and along the Missouri River. The beneficial effects on water hardness are quite substantial. Runoff during above-normal flow is obviously low in hardness, as it is in all dissolved minerals, and, of course, much of this water is stored for later release. The relative volume of water stored during the low-flow period of the year, when relatively hard ground water makes up practically all the inflow, is small by comparison.

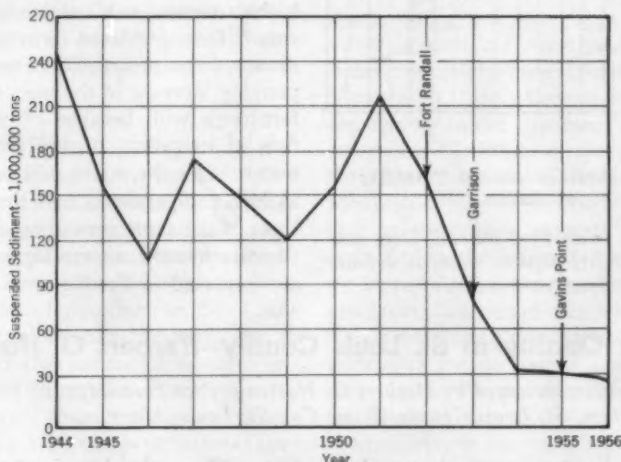


Fig. 7. Suspended Sediment at Omaha

Curve indicates the annual total suspended sediment load measured at Omaha, Neb., during 1944-56 as well as the effects of closures of the various dams, as indicated.

particularly after closure of Fort Randall in 1952.

The dams serve as tremendous settling basins in which most of the suspended matter settles out. They are especially effective in reducing turbidities resulting from intense summer rains of short duration.

In general, peaks and valleys of mineral concentrations are smoothed out so that waters of more uniform mineral

Therefore, Omaha's water supply from the reservoirs is spared the long periods of high mineralization that usually occur in summer and fall and, instead, is supplied with water of much lower mineralization.

Summary

In general, reduced turbidities during the years 1952-56 have not produced substantial savings in coagulants

as many thought it would. Since 1956, many factors—process changes, improvements, and enlargement of the

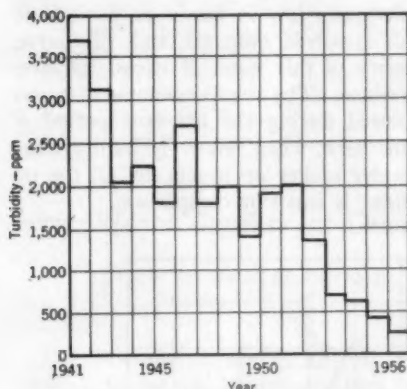


Fig. 8. Average Annual Turbidity at Omaha

After 1952, when Fort Randall Dam was closed, turbidity figures show a definite downward trend.

Omaha plant facilities—have contributed to variation in usage of treatment chemicals. The author believes that at the present it appears unjustified to assume that plant operations will consistently reflect changes in Missouri River water quality unless records cover a period of several years.

The net effects of the changes in turbidities and mineral content are not fully known at this time. Missouri River water after clarification is ideal for algae production in that it is rather highly mineralized and is enriched by runoff from fertilized farm land. The development of irrigation and accompanying increase in the use of chemical fertilizers will, because of the return flow of irrigation, further enrich these waters. As the water will be exposed to high temperatures and the long periods of sunshine prevailing during the summer months, severe algae problems are expected to develop.

—Water Quality at St. Louis County—Herbert O. Hartung—

A paper presented by Herbert O. Hartung, Vice-Pres.-Mgr. of Production, St. Louis County Water Co., St. Louis, Mo.

The St. Louis County Water Co.'s two purification plants on the Missouri River are 20 and 36 mi above the mouth of the river and about 800 mi downstream from Gavins Point Reservoir, the most southerly of the upstream main-stem reservoirs. The amount and quality of water in the Missouri River at the intake locations of the St. Louis County Water Co. are affected not only by the releases from the upstream main-stem reservoirs, but also by the flow contributions from the downstream tributary rivers. Water quality in St. Louis County is only partly influenced by the presently operating Missouri River basin control sys-

tem. Thus, the beneficial results of upstream basin control are somewhat less spectacular than those reported at Kansas City.

Control of Flow

This fact is better understood by comparing the flow quantity of water in the river at Kansas City and at St. Louis. During 1955–57 the average flow in the Missouri River at Kansas City was 31,000 cfs. In St. Louis County, the average flow was 43,000 cfs, or 40 per cent greater than at Kansas City. Similarly, the minimum flow of the Missouri River at Kansas City was 6,500 cfs, and at St. Louis County

the minimum flow was 12,000 cfs, approximately double the Kansas City minimum flow.

The flow additions of the tributary rivers to the Missouri River between Kansas City and St. Louis cause water characteristics at St. Louis County to be different from those at Kansas City. As an illustration, the average hardness of Missouri River water at Kansas City during 1955-57 was 220 ppm, and at St. Louis County the average hardness was 200 ppm. The average turbidity of Missouri River water during the same period was 700 ppm at Kansas City and 600 ppm in St. Louis County.

Water Quality

Missouri River basin control policy has been to release during the winter months somewhat constant amounts of water from reservoirs into the lower river. These controlled releases have had an important effect at St. Louis County in minimizing the variations in river water characteristics which originate in the upstream drainage area. Water quality characteristics are nevertheless still subject to variations, corresponding to variations in flow and water quality of the downstream tributary rivers.

The most noticeable effect of the Missouri River basin control on water quality in St. Louis County is a more uniform and less turbid water. For example, during the 4 years prior to the closing of the Fort Randall Reservoir (1948-51), the average river water turbidity was 1,600 ppm. The maximum water turbidity equalled 10,000 ppm. During the 5 years following the closing of Fort Randall Reservoir (1953-57), the average and maximum water turbidities were 700 ppm and 6,000 ppm, respectively. For

the 2 years following the closing of the Gavins Point reservoir (1956-57) the average turbidity dropped to 550 ppm and the maximum turbidity was 5,000 ppm, more than a 50 per cent reduction from turbidities before closure. Minimum river water turbidities in the winter are now often as low as 20 ppm.

Effects on Treatment

A clearer river water has been beneficial, but has also caused operating problems in the treatment plant. The lower turbidities have apparently resulted in taste and odor problems, for tastes and odors have been more frequent in St. Louis County water since the closing of the upstream main-stem reservoirs. It has been speculated that the clays from the Dakotas, causing Missouri River water turbidity, have had an adsorptive capacity for taste- and odor-producing compounds. With the removal of these clays in upstream reservoirs, taste- and odor-causing materials introduced downstream from the reservoirs are no longer adsorbed and now reach the purification plants in St. Louis County.

Similarly, it has also been observed that the ammonia-nitrogen content of the river water has increased since the closing of these reservoirs. The periods of high ammonia in the river coincide with very low water turbidities, and likewise low ammonia content coincides with high turbidities. Before closure of the reservoirs, the average and maximum ammonia contents in the river were 0.1 ppm and 0.28 ppm, respectively. Since the closure of the reservoirs, the average and maximum ammonia contents have been 0.2 ppm and 1.35 ppm, an increase of more than 100 per cent.

The increased tastes and odors and ammonia in the river water have caused

a change of emphasis in purification plant processing. Prior to the establishment of the basin control system, taste and odor removal was not a major processing requirement, and free residual chlorination control usually was not considered necessary. At present, however, the situation is different. Former emphasis was on presedimentation and turbidity removal. Although these are still important treatment plant processes, taste and odor removal is now also a major laboratory consideration.

On the other hand, the lower and more uniform turbidities in the river water are an important advantage to the treatment plant. The sudden and high increases in river water turbidity in former years caused a number of disagreeable coagulation and filtration problems. Emergency changes in chemical treatment and coagulation to combat sudden change in river turbidity are now much less frequent.

Another advantage of the Missouri River basin control system to water

plant operation is the control of floods which have their origin in the upstream drainage area. This advantage has not been fully appreciated to date because since the Garrison and Gavins Point dams have been completed, there apparently has not been a rainfall runoff condition comparable to those which caused flooding in St. Louis County in the past. Corps of Engineers' records show that, in July 1957, the level of a minor flood was 5 ft lower than it would have been without the basin control system in operation.

Conclusion

Ammonia content and turbidity are the primary water quality characteristics which have changed since the completion of the reservoirs. There has not been sufficient time to determine whether or not other river water characteristics have been altered. Observation and laboratory data must be evaluated against rainfall and river flow quantities over a period of years before other conclusions can be made.



Recreational Development on the Lower Colorado River

Robert K. Coote

A paper presented on Apr. 21, 1958, at the Annual Conference, Dallas, Tex., by Robert K. Coote, Staff Asst., Technical Review Staff, Dept. of the Interior, Washington, D.C.

CONSTRUCTION of Hoover, Davis, and Parker dams greatly reduced the magnitude and frequency of floods along the lower Colorado River. The stabilized flow of nearly clear water has made the river and the lands along it very attractive for general recreational use. The river is unique, scenically and recreationally, as the only large clear-water stream in the entire southwest desert area of the United States. The addition of large lakes to the combination of desert, mountains, and sun has made the area a source of pleasure and relaxation. Within easy driving distance of large and growing populations in both Arizona and California, the lower Colorado is attracting increasing numbers of vacationers from these areas, as well as from many of the more distant states.

Technically, the lower portion of the Colorado River starts at Lee Ferry, located upstream from the Grand Canyon, close to the boundary between Arizona and Utah. This article is concerned, however, only with that part of the river beginning with Lake Mead and discusses particularly that portion of the valley from just below Davis Dam to the international boundary with Mexico.

The lower Colorado River has not always been the reasonably benign stream that it is today, nor have its attributes and potential always been appreciated. Discovered in 1540 and used briefly for steamboat navigation after the establishment of Fort Yuma in 1851, no extensive development of the lower river took place for many years. In 1857, a Lt. Ives, on instruction from the War Department, made his way up the river by steamboat to the vicinity of what is now Hoover Dam. His disenchantment with the river seems to have been complete. He reported:

The region last explored is, of course, altogether valueless. It can be approached only from the south, and after entering it, there is nothing to do but leave. Ours was the first, and doubtless will be the last, party of whites to visit this profitless locality. It seems intended by nature that the Colorado River along the greater portion of its lone and majestic way shall be forever unvisited and unmolested.

Before the present dams were built, the flow of the Colorado was extremely erratic, varying from about 4,000,000 to 22,000,000 acre-ft annually, as measured at Lee Ferry. Such a wide fluctuation, attended as it was by alternat-

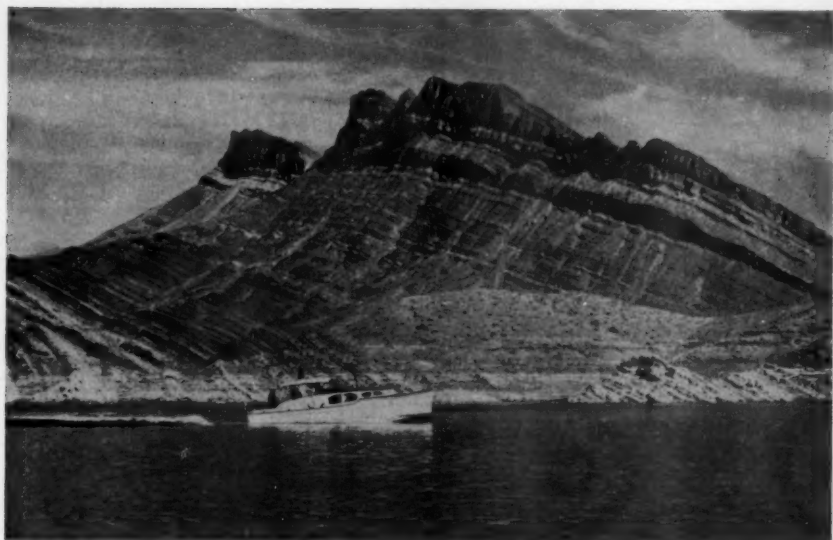


Fig. 1. Boating on Lake Mead

The combination of water and scenery makes the Lake Mead area particularly attractive to visitors.

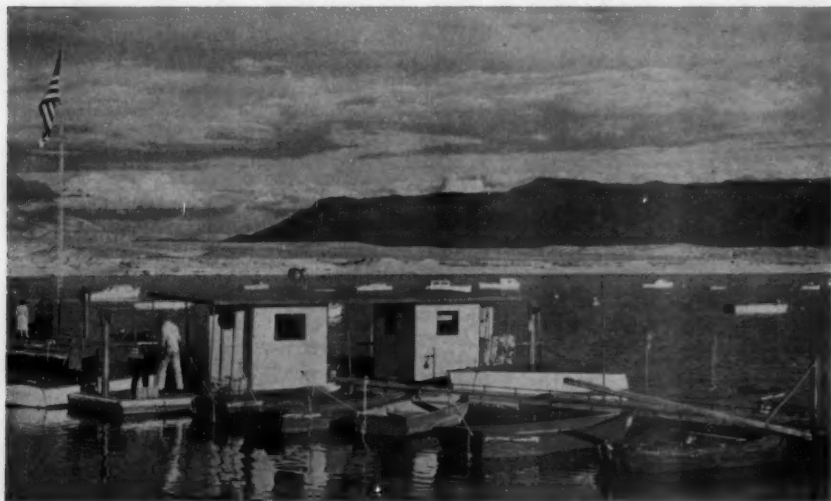


Fig. 2. Boat Dock on Lake Mead

Facilities of this nature are provided for fishing enthusiasts by private concessionaires that have been approved by the National Park Service.

ing low flows and destructive floods, made control of the river necessary. The US Bureau of Reclamation has carried out this work under authority of the Boulder Canyon Project Act.

The key to control of the lower river is Hoover Dam, completed in 1935. Hoover Dam stores water in Lake Mead for release as required for irrigation, power, and domestic use. Davis Dam, 67 mi below Hoover, forming Lake Mohave, reregulates the water released from Hoover Dam. Below Davis Dam are four diversion dams: Parker Dam, which forms Lake Havasu and supplies water for the Metropolitan Water District of Southern California; Headgate Rock Dam, for the Colorado River Indian Reservation; Imperial Dam and Mittry Lake, for the All-American Canal system and the Gila project; and Laguna Dam, for the Yuma project. A recently completed weir near Blythe, Calif., diverts water for the Palo Verde irrigation project.

Although the primary purpose of the dams is to control the naturally turbulent and unpredictable river and thus provide dependable water for irrigation, to prevent destructive floods, to furnish electric power, and to provide water for domestic use, it was early recognized that this development would result in outstanding recreational facilities. Thus, in 1936, shortly after completion of Hoover Dam, there was established the Lake Mead National Recreational Area. By agreement with the Bureau of Reclamation, the National Park Service administers the area and supervises recreational activities, plans, and developments. Both bureaus are agencies of the Department of the Interior. In 1947 the agreement was modified to expand the recreation area to include what is now

Davis Dam and its impounded reservoir, Lake Mohave.

Lake Mead Area

Lake Mead, the larger of the lakes in the recreation area, is about 115 mi long and has a shore line of some 550 mi. Lake Mohave is a narrow body of water, 67 mi long, reaching from Davis Dam almost to the foot of Hoover Dam.

The recreation area has been very popular since its establishment. Since 1937, the first year of National Park Service administration, when there were slightly more than 500,000 visitors, use of the area has steadily increased, except during the war period. For the year 1957, there were slightly fewer than 3,000,000 visitors, an increase of nearly one-third of a million over 1956. The visitors come to see Hoover Dam and to take advantage of the opportunities provided to enjoy water activities—fishing, swimming, boating, and water skiing—in a desert region (Fig. 1).

The National Park Service, as the administering agency, provides for the safety and comfort of the visitors, furnishing such facilities as access roads, swimming beaches, boat-launching ramps, camp and picnic sites, drinking water, and sanitation. Some of these facilities have been developed and are maintained by the National Park Service itself. Other facilities have been made available through approved concessionaires (Fig. 2).

Four main sites are located along the shores of Lake Mead. At the largest of these sites, free facilities include a bathing beach and lifeguards, picnic area, boat dock, and boat-launching ramps. Concessionaire facilities at this point include a trailer village, a beach house offering food,



Fig. 3. Lower Colorado River Valley

Recreational facilities below Hoover Dam have not been extensively developed, although the area still attracts vacationers.



Fig. 4. Water Skiing on Lake Havasu

Parker Dam is in the background. This is another area yet to be completely developed for recreation.

showers, change rooms, and bathing suits, a lodge with overnight accommodations, and a marina offering daily cruises, boat and motor rentals and services, and water skiing and fishing equipment. At the other three locations similar, although somewhat more limited, facilities are available.

Lake Mohave also has four main improved sites where both free facilities and those furnished by concessionaires may be used. Camp grounds, picnic areas, and boat-launching ramps are common to all the improved sites.

The existing facilities are inadequate. Camp grounds and picnic sites are too small, bathing beaches and their attendant facilities are overtaxed, and additional access to the shores of the lakes is needed. The National Park Service, as part of its Mission 66 program, plans to make these improvements. In addition, public use developments of a commercial nature, such as lodges, motels, restaurants, stores, trailer villages, and boating and fishing facilities, will be provided by concessionaires. At present there are approved concession developments at eleven locations within the Lake Mead National Recreation Area.

Southern Area

In contrast to the Lake Mead area, recreational use of the river and the abutting lands south of Davis Dam has proceeded with relatively little planning or administration. Below Davis Dam the Colorado River, on its course to the Gulf of California, passes through a series of broad valleys, separated by short, scenic canyons. Rugged barren mountains, typical of southwestern desert ranges, confine the valleys and separate the lower Colorado River Valley into a series of

distinct sections. The valley, in effect, is a long attenuated oasis. Its attractions are not of a spectacular order. No specific sections of its bottom lands possess unique or outstanding scenic qualities. The points of stream passage through the enclosing mountains, however, are very picturesque (Fig. 3).

The winter climate of the entire southwest region is a great attraction to vacationers. It is pleasant during the late fall, winter, and early spring, the winters being characterized by comfortable temperatures and sunny cloudless skies. This winter climate and other qualities of the lower Colorado valley below Davis Dam make it a desirable winter resort area. Little has been done, however, to make it attractive to winter visitors by providing the required recreational facilities. Accordingly, most of the visitors have gone to other nearby southwestern vacation lands, attracted by good accommodations and recreation opportunities.

Some planned, but not intensive, recreational use is made of the wildlife refuges and the Indian reservation. The Havasu Lake and Imperial National Wildlife Refuges, administered by the Fish and Wildlife Service by agreement with the Bureau of Reclamation, are administered primarily as waterfowl refuges. Both have recreational potential and developments, although recreation has been a secondary feature of their operation (Fig. 4). The refuges are intensively used at a few accessible points chiefly by fishermen and hunters. A few cabin sites have been leased on Lake Havasu.

Indian lands in the Colorado valley include the Fort Mohave, Chemehuevi Valley, Colorado River, Fort Yuma, and Cocopah reservations. Limited recreational developments are operated

on the Colorado River reservation by permission of the Indians. Other developments are contemplated there. Much more recreational use may be made of the reservation, as it offers good hunting grounds, fishing waters, camping areas, and potential resort sites.

There are no state or county parks in the valley, although negotiations are under way for the establishment of one or more.

The Arizona Game and Fish Commission leases Mittry Lake and vicinity, above Laguna Dam, as a wildlife restoration project. Other state wildlife projects along the lower river have been considered.

Privately owned lands with recreational values have been developed, to a small degree, by individuals. The existing local-use areas are largely on private lands near communities.

Flood Control

The major portion of the valley lands with recreational values, exclusive of the wildlife refuges and Indian reservations, is under the administration of the Bureau of Reclamation. Many years ago, in anticipation of the time when control measures to tame the unruly Colorado would be undertaken, the public domain lands on both sides of the river were withdrawn from all forms of appropriation and reserved for reclamation use. This withdrawal extended for some 6 mi back from both sides of the river. With completion of Hoover, Davis, and Parker dams, there was no longer need for such a large withdrawal, and most of this land was restored to the public domain. The withdrawal now consists of only a narrow strip, sometimes less than a $\frac{1}{2}$ mi

wide, immediately adjacent to the river.

Although construction of the dams has practically eliminated flood danger, there is still the possibility of infrequent localized flooding. For example, the Bill Williams River, which enters Lake Havasu just above Parker Dam, has, in the past, produced flash floods of great magnitude. Annual flows ranging from approximately 12,000 to 307,000 cfs have been recorded. A major flood of the Bill Williams River may require releases from Parker Dam in excess of downstream channel capacity.

Continuing channel rectification work will be required as the regimen of the river continues to alter. Thus, both for flood control purposes and for future channelization, it will probably be necessary to retain the present withdrawal for some time to come. This is not to say that the lands will be closed to other compatible uses, the principal one of which is recreation. The river from Davis Dam south to the international boundary is considered to be of interstate and regional importance for recreation. The overall problem is how to realize the fullest recreational potential of the withdrawn lands within the limits imposed by the requirements for flood protection and future river control.

Ownership and Use

Other problems which must be met and solved have to do with land, water use, and people. Many of the lands along the river are of uncertain ownership. Due to changes in the river's course and, occasionally, due to the absence of official surveys, ownership of a substantial acreage is in doubt. A determination as to which of these

lands are public lands of the United States involves a study of the various changes in the river channel over the years and official cadastral surveys.

Surveys are in turn linked to the now uncertain boundary between Arizona and California. Until a boundary is definitely established it will not be possible to close the surveys against the boundary. Also, until a boundary line is finally adopted and approved, there will remain jurisdictional questions which have a bearing on the use of the withdrawn lands. Fortunately, the boundary matter is moving toward a solution; boundary commissions of the two states have been at work for several years.

Another problem has to do with the use of water for the recreational development. All the waters of the lower Colorado are subject to legislation, compacts, treaties, and to the water laws of the abutting states. The waters of the river are in litigation between Arizona and California. Although the consumptive use of water for recreational development, primarily water for domestic use, would be very small and the removal of water-wasting vegetation might actually save water, there have been protests against any such use. Indications are, however, that this matter may cease to be a serious problem.

Trespass

Programing and planning for the recreational use of the reclamation-withdrawn lands along the lower river have also been complicated by the extensive use of lands in trespass. In the tradition of the Old West, when the preemption laws were in effect, hundreds of persons moved onto the fed-

eral lands and appropriated them for their own use. This trespass is of two general types—occupancy trespass for residential or commercial purposes and agricultural trespass. In connection with the latter, much unauthorized use of Colorado River water for the irrigation of both federal and private land has taken place. Because of the acreages and values involved and because cultivation depends on water diversions for irrigation, the agricultural trespass constitutes the more serious problem. For this discussion of recreation, however, the main concern is with occupancy trespass.

As might be expected, the trespassers, or squatters, have chosen the more scenic and recreationally desirable areas for their camp sites, shacks, cabins, trailer courts, fishing lodges, and for other purposes, private and commercial. Many of the squatters fence off considerable sections of the desirable river frontage, depriving the public the use of this land and access to and along the river banks. The squatter situation has reached such proportions as to attract national notice.

Mainly, because of this trespass occupancy, a recreational development program for the lower river, acceptable to all concerned, has not been an easy task. The Department of the Interior has been working on the problem for some time. In cooperation with the states of Arizona, California, and Nevada, it made a study to determine the most beneficial use to which the reclamation withdrawn lands could be put. It was concluded that, in general, the lands were best suited for recreation and wildlife. There were and are, however, various points of view and

conflicting interests. Not only is there competition between those now using the lands and those who would like to use them, but there are also conflicts of interest between the states and between state agencies, and sometimes between agencies of the same state. Obviously, to be accepted, a program must be one that all interests can live with, even though it fails to satisfy fully the desires of any particular group.

Proposed Development

The program which the Department of the Interior now has under consideration gives recognition to the full recreational potential of the lower Colorado River Valley by designating the reclamation withdrawn lands south from Davis Dam as the Lower Colorado River Interstate Recreation Area. This arrangement is somewhat similar to that now in effect for the lands being administered as the Lake Mead National Recreation Area.

To bring this proposed general recreational program into clear focus, a lower Colorado River survey unit of the National Park Service has been engaged in an inventory of the recreational resources of the lower river, the preparation of land use plans for the lower river as a whole, and detailed plans for certain segments of the river which are of immediate interest and significance for recreation. The first of these units for which a detailed study has been made and for which preliminary plans have been prepared is comprised of that stretch of the river between Parker Dam and the northern limit of the Colorado River Indian Reservation, designated as the Parker Dam Unit. A similar land use plan has been prepared for the Laguna Unit. Also, the

park service, cooperating with the Indians, has prepared a detailed plan for the recreational use of the northern portion of the Colorado River Indian Reservation. Considerable progress has been made on the planning of other units, including the area within the Lake Havasu Wildlife Refuge.

Although, under the program, initial administration of the entire area during the development stage would be under the National Park Service, as is the Lake Mead Recreational Area, the development of an interstate program and organization to take over the management of the recreation resources as soon as possible would be encouraged. Already there has been considerable interest expressed on both sides of the river in this possibility.

To insure full recognition of state and local interests, the plan proposes the creation of an advisory committee to consult with and assist the administering agency. This committee would consist of federal, state, and local officials and representatives of groups and interests in the area. In this manner the program would be responsive to local needs and conditions. Municipal, county, and state management of particular areas would be encouraged.

There are several other points in the program to which special attention should be called. The reclamation-withdrawn lands must, of necessity, remain available at all times to the Bureau of Reclamation for use and development in connection with the delivery of water under the Boulder Canyon Project Act, including river rectification. Any development for recreational purposes would be coordinated with and made subject to the plans of the bureau.

The federal wildlife reserves (Lake Havasu and Imperial), and the Indian reservations (Fort Mohave, Chemehuevi, Colorado River, and Yuma), would not be included in the proposed recreation area. Their facilities for recreational use, however, would be closely integrated with the program.

The general approach to the commercial trespass situation would be one of gradually fitting the present trailer park, motel, lodge, and other facilities serving the public into the framework of a master plan. To a large extent, commercial developments would be permitted to remain in their present general location, but as a general policy all lessees would be required to vacate a strip 200 ft back from the river. They would also be required to bring their sanitary and other facilities up to acceptable standards. Details of such a plan would give high priority to public recreation facilities and services and to the designation of suitable homesite areas for lease to the public, including the present users, on a reasonable lease basis.

Detailed Planning

Efforts at detailed planning were therefore begun with the Parker Unit, an 11-mi stretch of river with superior scenic and recreational values, just below Parker Dam. Within this area is also located the greatest concentration of squatters to be found along the river. The general scheme of development for the Parker Unit anticipates public use of a major portion of the land, initially under the management of the Park Service. The northern portion is considered to have state park potential, because it is the more rugged and spectacular. The southern, more

level part can be used to a greater extent for residential and commercial uses without impairment of public recreational values. According to the plan, areas are zoned for public, commercial, and residential use. Intervening and surrounding areas are left for public access and buffer strips. Under the program, most of the residential use would be eliminated from the area or relocated away from the river bank where it is now concentrated. Most of the commercial establishments in this area would be incorporated into the development program.

The proposed creation of a 200-ft public access strip over the federal lands along both banks of the river has aroused considerable opposition. No doubt such a strip would result in some dislocations. The 200-ft strips have never been suggested as an absolute requirement for the whole length of the lower river, however, but rather as an optimum objective toward which to plan. Certainly there is no intention to take such arbitrary action as would cause undue hardship for those now occupying parts of such strips. Recognition would be given to the time, money, and effort which have been spent in developing properties on federal lands along the river and to the services performed by the commercial establishments in furnishing lodging and other facilities to the public. Situations can be expected where it would be necessary to require higher standards or some modification and relocation of existing commercial facilities. It may become necessary to clear some tracts when needed for the development of public use areas. Every effort would be made, however, to keep relocations to a minimum and, when nec-

essary, to offer alternative sites which may be occupied under lease or permit.

Summary

The author has described briefly what has taken place in the way of recreational development along the lower Colorado, the steps that have been, and are being, taken to meet the ever increasing demand for recreational facilities in the area, and some of the problems that must be faced if the demand is to be met. The growth of recreation within the Lake Mead National Recreation Area would seem to indicate clearly the comparable in-

creasing future use of other parts of the lower river for which no records are presently available, especially if facilities and accommodations are provided to the public in the relatively undeveloped stretches of the river. The attractiveness of the lower valley, coupled with a growing population, with leisure time, and the means to enjoy it, is a combination which should result in the lower Colorado making an outstanding recreational area. Certainly, it has already disproved the early prediction that it would be "forever unvisited and unmolested."

Correction

Following publication in the April 1958 *JOURNAL* of the statement on asbestos-cement pipe in the "Report of the Committee on Water Works Practice," Charles A. Koons, president of Italit, Inc., 620—5th Ave., New York, N.Y., has made available to the Committee on Water Works Practice copies of the following reports:

1. Jersey Testing Laboratory report No. 3394, dated Oct. 18, 1955
2. Underwriters' Laboratory report No. 2028, dated Jun. 11, 1957.

The Jersey Testing Laboratory report covers Class 150 asbestos-cement pipe in sizes 6, 8, 10, and 12 in. The Underwriters' Laboratory report covers 6-in. and 8-in. pipe. The class of pipe tested is not indicated in the Underwriters' Laboratory report, but the tests applied indicate that it was Class 150 pipe.

The Jersey Testing Laboratory, as well as the Underwriters' Laboratory, reported that the samples of Italit pipe furnished by the manufacturer and tested by the laboratories conformed to AWWA Standard C400-53T.

Monitoring of Stream Water Quality

Panel Discussion

A panel discussion presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex.

Introduction—Herbert O. Hartung

An introductory statement by Herbert O. Hartung, Vice-Pres. & Mgr. of Production, St. Louis County Water Co., St. Louis, Mo.

THE AWWA statement on national water resources policy (1) declares that first priority in the use of the nation's water resources should be given to providing water for the people—for use in their homes and urban activities. The statement, in respect to this point, adds that the prevention of waste and the reduction of pollution to its lowest practicable level are most important. Stream water quality-monitoring programs are tools useful and important for the implementation of this policy.

The increase in the amount and kinds of pollution entering streams has become a serious problem. Old concepts regarding the self-purification of streams and rivers and the propriety of disposal of wastes by dilution are no longer valid. It is common knowledge that, even in major streams and rivers, there is no longer sufficient water for both water supply and water disposal by dilution. The public water supply industry, therefore, must be vigilant against conditions which cause impairment of drinking water sources, and it is for that purpose that water quality programs are designed.

Program Objectives

The monitoring programs have, in general, these specific objectives:

1. To learn stream water chemical, physical, and bacteriological characteristics under changing conditions
2. To define stream water pollution problems in terms of amounts, frequency, and kinds of pollution
3. To assess the significance and possible harm to water supply and public health of pollution in streams
4. To pinpoint, when possible, the sources of pollution entering a stream
5. To detect pollution spills harmful to water supply—such as occur with occasional oil pipeline breaks, refinery and other industry pit releases—and then to alert downstream water plant operators of the impending crisis
6. To determine background quantity data on certain types of wastes—such as chlorides or radioactive materials—and to detect critical changes from normal
7. To procure data useful and necessary for securing public action toward the preservation of streams for water supply purposes.

Because of today's changing pollution problems, stream water quality monitoring must be extended beyond testing for coliform bacteria, biochemical oxygen demand, and oxygen depletion. These test procedures do not measure many of the pollutants now entering watercourses. The extensive use of synthetic detergents, the much increased use of petroleum products and heavy metals, and civilian use of radioactive materials and many other products require that additional and new tests and techniques be used in monitoring. Tests which measure pollutants which have taste- and odor-producing potentials are also important.

One of the most promising of the new tests for measuring some types of pollution in streams is the USPHS carbon filter and chloroform-alcohol extraction technique. This test enables the measurement of very small amounts of organic matter in water. Research is being contemplated, at Washington University in St. Louis, to determine means of better utilization of the carbon filter extract results. Improved instrumentation for continuous measurement of radiation is also being developed.

The water supply profession is particularly qualified for and must participate in stream water quality-monitoring programs for several reasons: [1] the water industry has a legitimate and proper interest in stream water quality because of its responsibility to the water consumer, [2] water-sampling facilities and laboratories are already equipped or are readily adaptable to water quality-monitoring programs, [3] the industry has the technical and professional capacities available for the conduct and evaluation of these programs, and [4] most important, quality monitoring is essential to the preserva-

tion of public water supplies—an end to which the profession is dedicated.

Monitoring of Missouri River

In December 1955, the Missouri River below Kansas City, during a period of low flow, was polluted with very disagreeable taste- and odor-producing substances to an extent not previously experienced. These tastes and odors were not totally removed in the water purification plants and were responsible for numerous consumer complaints. This experience very forcefully demonstrated that even the mighty Missouri River with its abundant water could no longer assimilate the ever increasing amount of pollution it was receiving. The importance of this discovery was immediately obvious to all water utilities on the river.

Faced with the important problem of how to cope with pollution, water utility operators along the river joined forces to work for a solution. The Missouri Division of Health and the Kansas City office of the USPHS gave organizational assistance by setting up a cooperative pollution-monitoring committee. The sanitary engineering department of Washington University, the Nebraska State Board of Health, and the Taft environmental health center of the USPHS at Cincinnati also supported the efforts of the committee and utilities.

The Missouri is now being continuously monitored by means of the USPHS carbon filter-chloroform extraction technique. Monitoring is done at and by the water utilities of Yankton, S.D.; Omaha, Neb.; St. Joseph, Mo.; Kansas City, Mo.; Lexington, Mo.; Jefferson City, Mo.; and St. Louis and St. Louis County, Mo. These eight monitoring stations are spaced along an 800-mi stretch of the

Missouri River, beginning 20 mi above its mouth.

In addition to carbon filter monitoring, the participants immediately notify the USPHS at Kansas City or the Missouri Division of Health when tastes and odors or any other evidence of unusual contamination are first noticed. These agencies then notify downstream water plant operators of impending pollution.

The objective of this pollution monitoring is at least threefold. The points of entry and the amount of pollution being added to the river are to be learned—with the goal of pollution abatement enforcement. The polluting materials are to be characterized as to chemical type or are to be specifically identified. Finally, an attempt is to be made to determine the critical amount of the polluting materials—that is, the amount that will cause troublesome tastes and odors. This is useful as a means of forewarning the water plant operator of taste- and odor-processing requirements. Another aspect, not yet under study, is the improvement of taste and odor processing and control in the water purification plants.

All of the eight monitoring stations were accumulating data by October 1957. Some monitoring data were also being reported before then. Already, the results have indicated the values of the cooperative study. An indirect benefit resulted when two industries, after learning of the monitoring program, voluntarily took steps to reduce their waste discharges into the river by utilizing impoundments and waste recovery processing.

The AEC works at Weldon Springs, Mo., is also cooperating with the monitoring committee by submitting on a monthly basis laboratory analyses of

daily discharges into the river from their operations.

Procedures

Two carbon filters are installed at each of the eight monitoring stations. One filter is for monitoring the raw river water and the other is for monitoring the treated water. Sampling is continuous from water flowing through the filters at the rate of about 0.25 gpm. Every 2 weeks—after sampling about 5,000 gal of water—the carbon cartridges are removed and chloroform extractions are made at either the Omaha, Kansas City, St. Louis, or St. Louis County laboratories. The recovered material is dried and weighed and the results are expressed in parts per billion of chloroform-soluble organics in water.

The weighed and dried residue from the chloroform extractions are then mailed to the sanitary engineering laboratory at Washington University in St. Louis. This laboratory is making quantitative organic group separations for further studies. The university is also beginning studies on improved methods of analysis for further identification of the substances in the chloroform extracts.

The USPHS at Kansas City serves the monitoring organization as data and procedure coordinator, submitting periodic data reports. The Taft environmental health center of the USPHS at Cincinnati is furnishing the committee technical assistance. It is to be expected that the mass of data being collected will enable this organization to make an effective contribution to the preservation of the Missouri River as a public water supply source.

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USPHS Program—Ralph C. Palange and Stephen Megregian

A paper presented by Ralph C. Palange, Asst. Chief, and Stephen Megregian, In Charge, Laboratory Services, Basic Data Unit, both of the Water Supply and Water Pollution Program, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

The need for fundamental information which can be used to establish long-term trends in water quality, and the usefulness of such data in overall planning are both well recognized.

The USPHS program for the collection of basic data on water quality has been previously described (1, 2). Briefly, Section 4(c) of Public Law 660 provides that the USPHS "shall, in cooperation with other federal, state, and local agencies having related responsibilities, collect and disseminate basic data on water quality insofar as such data or other information relate to water pollution and the prevention and control thereof." The objective for fiscal year 1958 was the establishment of 50 water-sampling stations on the Great Lakes and interstate streams of the United States. At each of these stations, samples of raw water are collected periodically and analyzed for radioactivity, organic chemical content, plankton populations, coliform organisms, and the conventional physical and chemical qualities. This last group includes temperature, dissolved oxygen, pH, BOD, chemical oxygen demand, chlorine demand, ammonia nitrogen, chlorides, alkalinity, hardness, color, turbidity, sulfates, and total dissolved solids. Later, the program will include data on populations of fish and other aquatic organisms.

Pilot Network Operation

Before initiation of this program, the USPHS established a pilot network of ten stations across the United States.

The principal objectives of this network were:

1. To develop a base from which the broader national program could be expanded
2. To provide preliminary data on waters of widely differing quality, for use in selecting laboratory procedures
3. To provide an opportunity for discussing the broad concept of such a program in various parts of the United States, thereby obtaining advice and comments valuable in the development of the broadened program.

Although the pilot network was operated for only about 6 months, the data gathered were sufficient to yield useful information, including differences in pollutional levels between river basins, as well as within the same basin. The data are presented in Fig. 1 and include results for radioactivity, total algae, and organic chemicals at eight of the ten stations sampled.

Organic Chemicals

When several thousand gallons of water are passed through a filter containing activated carbon, the organic chemicals present are adsorbed onto the carbon. Removal and recovery of the organics from the carbon are accomplished by extraction with chloroform and then with alcohol, in accordance with the technique developed by Middleton and others (3, 4). Organic pollutants originating from the various chemical manufacturing industries, as well as petroleum-based pollutants, are

recovered in the chloroform extract. The alcohol extractables contain detergents, as well as materials originating from algal activity, organic matter in soil, decay of vegetation, and other natural sources.

Fig. 1a shows the concentrations of chloroform and alcohol extractables recovered from eight stations. The Colorado and Columbia rivers contain the lowest concentrations of organics—especially the chloroform extractables. The Detroit and Merrimack rivers had many times higher concentrations of total organics—particularly the chloroform extractables. This shows that both streams receive considerable industrial pollution above the sampling sites.

The Mississippi and Missouri rivers lie between the two extremes. The three Mississippi River stations show about the same concentrations of organics at Minneapolis, Quincy, Ill., and New Orleans, which indicates a counterbalanced effect between new pollution, assimilation by the stream, and increasing flows.

Plankton and Algae

Total algae are presented in Fig. 1b. The highest counts were experienced on the Mississippi River at Quincy, where a maximum of 142,000 per milliliter occurred in March 1958. Counts above 10,000 and 17,000 were experienced on the Mississippi River at Minneapolis and on the Missouri River at Kansas City, respectively. The organism predominating at most of these stations throughout this period was *Cyclotella*, which is well known as a taste and odor producer and as a filter clogger. Many other forms were identified. *Dinobryon* and *Peridinium*, notorious for taste and odor production in water supplies, were dominant in

two of the streams during May and June. Other dominant forms included *Melosira*, *Asterionella*, *Stephanodiscus*, *Navicula*, *Diatoma*, *Synedra*, *Chlorella*, *Scenedesmus*, and *Ankistrodesmus*. A number of these are particularly important as filter-clogging organisms. At several stations, significant numbers of protozoan ciliates, rotifers, and crustacea were also present, in addition to the algae.

Radioactivity

Fig. 1c presents the total beta radioactivity counts. Levels are above normal background at the Columbia River station because it is located downstream from the Hanford Works of the AEC. Although the counts are above the provisional levels of permissible concentrations (5) recommended for use beyond the control area, the activity at this station is principally due to short-lived, induced radioactive materials which have higher permissible concentrations individually.

The levels occurring during June on the Missouri and the Mississippi rivers were much higher than the normally experienced background. Several nuclear-weapons tests occurred in Nevada during June. Prevailing winds evidently carried the radioactive materials in an easterly direction. The high counts at Kansas City and at Quincy, Ill., reflect the fallout due to these tests. The lower levels at New Orleans reflect a combination of natural decay, assimilation by stream life, and dilution of the materials introduced at the upstream points.

Other Areas

Operation of the pilot network pointed up several needs. A problem which must be resolved before a more comprehensive program can be devel-

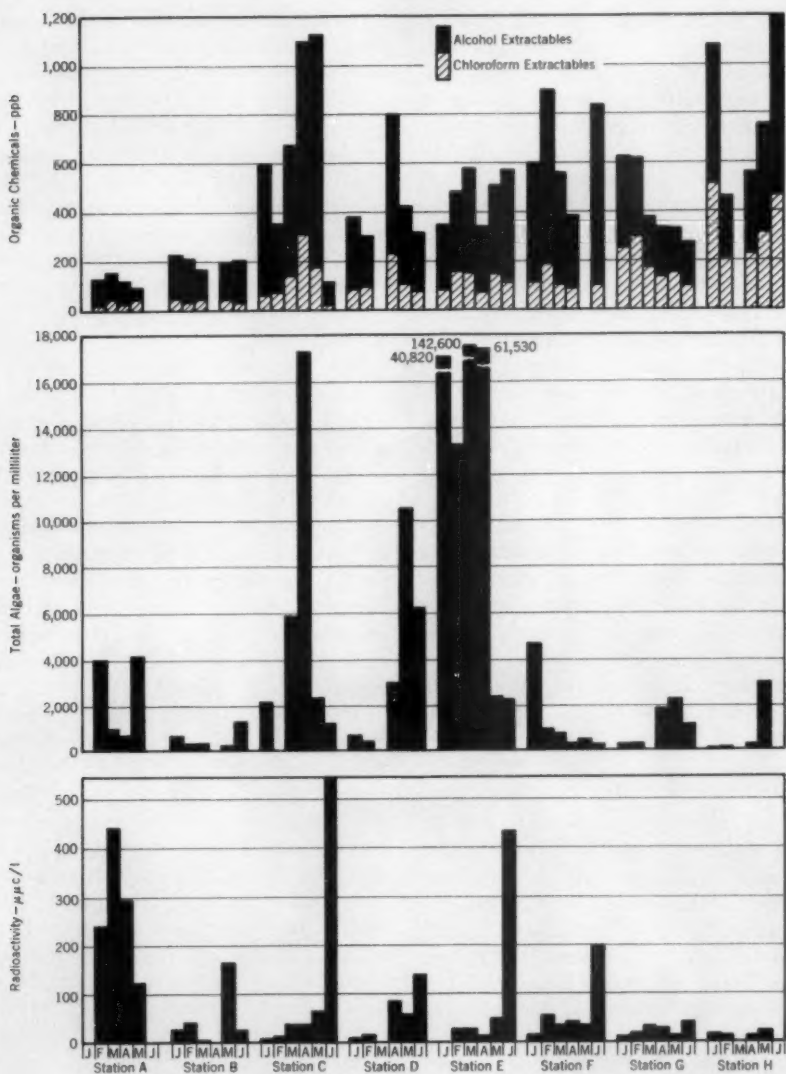


Fig. 1. Organics, Algae, and Radioactivity Detected at Eight Stations

Concentrations of chloroform and alcohol extractables are shown in Fig. 1a, total algae in Fig. 1b, and beta-radioactivity counts in Fig. 1c. All samples were taken in 1957 at the following stations: A, Columbia River—Bonneville, Ore.; B, Colorado River Aqueduct; C, Missouri River—Kansas City, Kan.; D, Mississippi River—Minneapolis; E, Mississippi River—Quincy, Ill.; F, Mississippi River—New Orleans; G, Detroit River—Wyandotte, Mich.; H, Merrimack River—Lawrence, Mass.

oped to its maximum value is automatic instrumentation at the sampling site. Some of the more significant parameters of water quality, such as temperature, pH, dissolved oxygen, and the various demand measurements, are fugitive in nature and fluctuate continuously through the influence of hourly changes in air temperature, sunlight intensity, stream flow, and other natural factors. It is highly important that maxima and minima be recorded, since these may not be represented by analyses of periodic grab samples. Every effort should be made to develop instrumentation to provide these data.

Another important need, and one which will become more urgent as the rate of water use increases with the economic development of the nation, is that of new parameters which can be used more effectively in the future evaluation of water quality. It is well known that tremendous increases in water use have occurred because of recent rapid economic expansions. These expansions have already placed additional strains in areas of water shortage. What is most important, however, is that the wastes emanating from many of these new sources are fundamentally different from wastes which water pollution control authorities have dealt with in the past. New, simple, and meaningful parameters must be used to characterize these new and often insidious pollutants. One such parameter already in use is the carbon filter technique for the measurement of organics in water. Other techniques are needed now to provide new armament with which to attack the rapidly increasing problems of water quality evaluation.

Present Program

The present USPHS program evolved from the pilot study. By Apr.

1, 1958, 44 stations had been established and were in operation. Negotiations were under way for an additional six stations to complete the initial 50 stations of the nationwide water quality program. Fig. 2 shows the location of the stations in the expanded network.

Water users at the sampling sites have been integrated into and are actively participating in the operations. Of the 44 stations already established, 40 are located at intakes of existing water treatment plants or utilize the manpower of a nearby water plant, or both. In most instances, the water plant involved is contributing not only the personnel services needed for the collection and shipment of the various samples to USPHS, but also, on a weekly schedule, the analytical data on raw water covering conventional chemical and physical examinations previously enumerated. In several instances, water departments have volunteered their cooperation even though they do not use the stream as a source of raw water. Others participating directly in the program include three state health department laboratories, four local health department laboratories, one sanitary authority laboratory, six federal agencies other than the USPHS, and four industrial establishments.

The water quality basic-data program will not remain static. As new parameters are developed and are found significant, the program will be modified accordingly. New tests will be included and old ones dropped whenever the need arises. Certain areas may require additional special analyses. Other areas may need less intensive effort. The information that a program of this type produces can be most useful only if it is kept current with new developments.

Summary

Examples have been given of what water quality data developed on a nationwide basis can show. A program of this type should not be considered a monitoring or surveillance program; a better name for it would be "intelligence service." It should provide the means for continuous evaluation of the quality of water resources so that when any necessary corrective action is indicated, a warning or "alert" can be flashed. This warning should designate the general area needing relief and the degree of correction necessary. The basic-data program is not intended to and should not take the place of detailed field surveys required for the solution of local problems.

The federal network will provide data for interstate and international streams and for areas affected by federal installations. These data will be issued annually in a government publication available to all. It is hoped that the states and other local agencies responsible for water resources will develop intrastate programs which can be linked with the national network, with the federal stations used as reference points.

In addition to the principal benefits to be gained through the collection and publication of these fundamental data, the program has already stimulated activities at many water plants. This activity has resulted in more comprehensive laboratory coverage and increased

utilization of the newer parameters for assessment of water quality. Also, through the USPHS analytical reference service, participants in this program have an opportunity to evaluate the precision and accuracy of their own laboratory data. Another benefit is thus gained by the improvement of laboratory competency.

It is presently anticipated that the USPHS responsibility can be adequately covered by a maximum of 250-300 stations. When supplemented by intrastate programs, these should provide the data necessary for all future efforts aimed at the preservation and maximum utilization of the nation's water resources.

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—Development of a Robot System—Edward J. Cleary—

A paper presented by Edward J. Cleary, Exec. Director & Chief Engr., Ohio River Valley Water Sanitation Com., Cincinnati, Ohio.

The author's purpose here is to describe briefly some past experiences and future aspirations in devising (or, to use a term of his own coinage, "imagineering") a system for auto-

matically analyzing, recording, and transmitting data on water quality conditions in a river. In order to understand the purpose and desirability of such an undertaking, one has only to

consider the extent of the Ohio River system, which has a main stem almost 1,000 miles long and nineteen major tributaries. Quality conditions in this river are strongly affected by waste discharges from thousands of industries and municipalities and are influenced by a host of natural variations. The quality of the Ohio River has a profound effect on the almost 2,000,000 people who depend on it for a potable water supply and on industry, which alone requires 11 bgd.

It is the complicated nature of this river system that has suggested the possibility of devising a robot monitor network that will make possible advance notice of quality variations. By means of such monitoring, a central office—such as that maintained by the Ohio River Valley Water Sanitation Commission—will be able to alert water treatment plant operators and other water users of changes in river quality in time to allow them to schedule adjustments to cope with the anticipated variations.

This is not an academic concept. Six years' experience on the Ohio River with a network of monitor stations—probably one of the most extensive in the nation but, nevertheless, rather crude as compared with the envisaged system—has provided many instances where advance notice of stream changes has benefited downstream treatment plants. Virtually in every instance where the commission has been able to alert water plants to changing quality conditions, this has aided operators to take appropriate steps for minimizing difficulties in producing a palatable finished water.

One of the questions under exploration is: Exactly what are the parameters of change most useful in guiding the operation of an Ohio River water plant? For example, would specific

conductance, chlorine demand, hydrogen ion concentration, and oxidation-reduction potential measurements best serve this purpose? The goal, of course, is to select a minimum number of significant parameters, as securing and transmitting data is not inexpensive.

There is considerable positive anticipation of the use of the robot monitor system. Perhaps it is justified, too, when one considers that a major problem of the purveyor of water is the converting of a raw material whose quality varies from day to day into a uniform product. Any system that would permit some advance information on changes—and, perhaps, the anticipated rate of change—of quality of the raw material could mark one of the most useful advances in water supply practice.

Alerting water users of quality changes, however, is only one application of this system. From the standpoint of those who are charged with administration of pollution control—as is the Ohio River commission—development of a robot monitoring station offers opportunities to move out of the primitive stage of operation. Dealing with the dynamics of river use and reuse, it seems anachronistic to continue to rely on sporadic stream surveys and catch-as-catch-can sampling for data that is vital to the safeguarding of water resources.

This is not intended to suggest that all orthodox sampling and laboratory operation are outmoded. Far from it; but there is little need to be chained to the many routine and time-consuming tasks that are essential to the conduct of a conscientious job. Automatic devices free men, their minds, and their hands for more creative and satisfying endeavors.

Furthermore, in connection with the discharge of certain industrial waste

effluents, both industrial managers and regulatory agencies could find common justification in securing a more positive accounting of what is discharged into a stream. In fact, when these devices are perfected, it would not be illogical for installations at industrial plants to be integrated into a regional network—such as that envisioned for the Ohio River Valley.

Scope

For these and other reasons the staff of the Ohio River commission is enthusiastically engaged in the design of a robot monitoring project. Work has been actively pursued for 18 months. Broadly speaking, staff efforts are directed toward an investigation of the engineering and economic feasibility of adapting analytical instruments for the continuous recording and automatic transmission of river water quality data and the development of a self-operating monitor station for this purpose.

The investigation is designed to:

1. Determine the availability and applicability of analytical recording equipment
2. Outline possibilities for development of equipment not now available
3. Test and operate under field conditions various combinations of analytical recording instruments
4. Determine reliability of results from automatic analyzers by comparison with results from orthodox procedures
5. Explore the adaptability of various systems for recording, transmitting, and logging data at one or more central points
6. Make an appraisal of cost and feasibility factors related to the construction, installation, and operation of robot monitor stations.

Initial efforts have been directed toward determining the availability and applicability of analytical recording equipment. About 50 instrument manufacturers were asked what they had to offer and whether they would be interested in working with the commission on development of equipment not now available. Relatively little is available in the form of easily adaptable equipment and only a few manufacturers have been in a position to consider developmental work at this time. Several promising possibilities have been uncovered, however, and equipment is now being tested or readied for tests.

Acknowledgment

The basic inspiration for the project came from the author's association with Leon Small more than 20 years ago. Small was at that time chief engineer of the Baltimore water works. Certainly in 1937 no one provided more inspiring visions of what might be accomplished with automatic operating and transmitting mechanisms. His inventions and installations in Baltimore are definitely worth inspection by anyone who has an opportunity to see them.

Detailed responsibility for the investigation is currently assigned to William L. Klein, chemist-biologist of the commission staff. Assistance in guiding the work is provided by David A. Robertson Jr., engineer-hydrologist, who is in charge of the quality-monitoring network operations of the commission. Preliminary investigations were carried out by David Eye, of the University of Cincinnati, who serves as a part-time member of the staff. The investigation is being financed from a portion of a federal grant to the commission under Public Law 660.

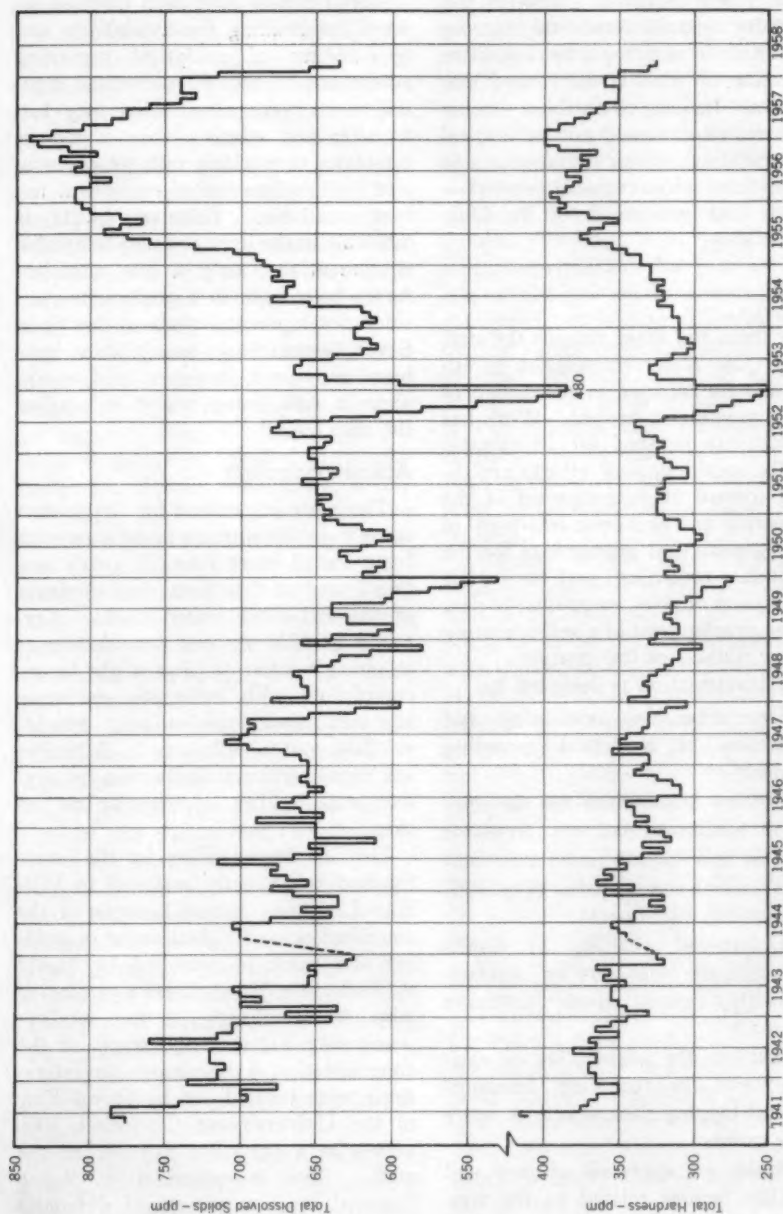


Fig. 3. Variation in Hardness and Total Solids of Lake Havasu Water

Data are based on chemical analysis of monthly samples.

Colorado River Aqueduct System—Lee Streicher

A paper presented by Lee Streicher, Chief Chemist, Metropolitan Water Dist. of Southern California, La Verne, Calif.

Because the Colorado River is more than 250 mi from the area in which its water is distributed by the Metropolitan Water District of Southern California (see Fig. 1, p. 1122), the water quality-monitoring program adopted by the district provides for the examination of water samples taken at a number of points along the Colorado River Aqueduct system. All field samples are forwarded to the laboratory at the softening and filtration plant near La Verne, Calif., for chemical and biological or radiological examination, or both.

Chemical Monitoring

Several months before the district delivered the first Colorado River water to its member cities in June 1941, a program was initiated for sampling at Lake Havasu, where the aqueduct originates. Monthly collection of samples for chemical analysis has been continued since that time. The variation in total hardness and dissolved solids content of the water is shown in Fig. 3. It is interesting to note the gradual improvement in water quality from the early years of operation until 1953. When Lake Mead (behind Hoover Dam) and Lake Havasu were first filled, some of the salts underlying the reservoir areas were leached out and substantially increased the mineral content of the water. During the period 1943–53, runoff of fresh water in the Lake Mead watershed area was sufficient to reduce the concentration of dissolved salts, and the water quality closely approached its long-term average quality. The very rapid deteriora-

tion in water quality from 1953 to early 1957 is a direct reflection of the deficiency in precipitation and runoff in the Lake Mead watershed area in recent years. Only in the last year—1958—has the runoff increased to the point where an improvement in water quality can be noted. Although the changes in quality of Lake Havasu water—as determined by the monthly chemical analyses—have no immediate effect upon treatment procedures at the softening and filtration plant, these analyses give an indication of the quality of water which will be received at the plant and delivered to the member cities in the ensuing months.

From the five pumping plants along the route of the aqueduct, samples for chemical analysis are collected quarterly on a routine basis—mainly to follow the progress of the water through the aqueduct system. When the raw water reaches the treatment plant, samples are collected daily for partial chemical analysis and to provide aliquots for the monthly composite sample which is analyzed for all major chemical constituents. The variation in hardness and total dissolved-solids content of these monthly composite samples is shown in Fig. 4. The initial improvement and subsequent deterioration in Colorado River water quality (discussed above with reference to Lake Havasu water) is even more clearly defined here because of elimination of the variations inherent in grab sampling.

Samples are taken from the plant influent water at least every 4 hr throughout the day and night for tur-

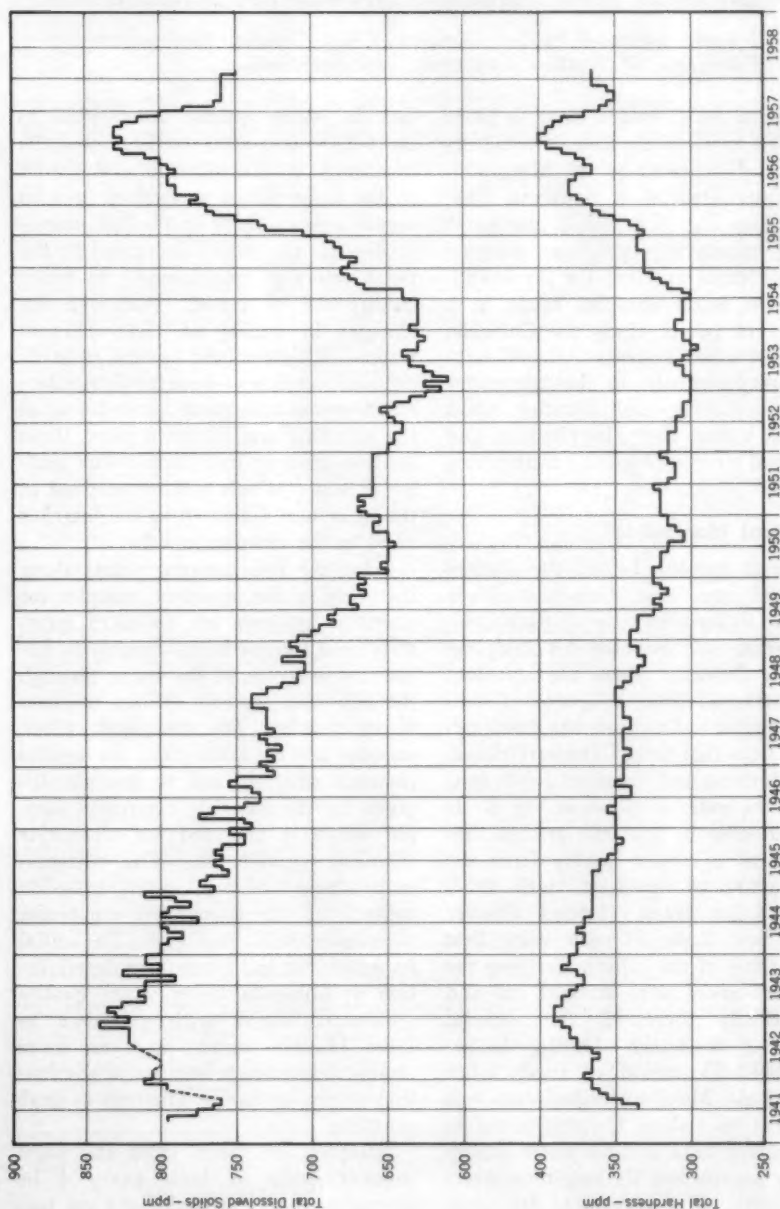


Fig. 4. Variation in Hardness and Total Solids of Water Received at La Verne, Calif., Treatment Plant

Data are based on monthly composite samples analyzed at the softening and filtration plant.

bidity determinations and from one to three times a day for taste and odor evaluation, as these characteristics can affect the treatment process. A hardness test of the raw water is run each day to determine whether adjustments are required in the softening step of the treatment process. As indicated above, because of storage and blending of the water in Gene Reservoir and Copper Basin Reservoir along the main aqueduct and in Lake Mathews—at the terminus of the aqueduct and start of the distribution system—Colorado

ommendations for copper sulfate treatment at the latter two are made on the basis of the findings. Lake Mathews—the immediate source of water for the treatment plant—is watched much more carefully. Here, samples are taken twice weekly—seven from different areas of the reservoir and one from the headwork adjoining it. Microscopic examination of these samples reveals when significant numbers of plankton appear in any section of the reservoir and spot treatment with copper sulfate is then used to avoid spread-

TABLE 1
Gross Radioactivity in Colorado River Water

Fiscal Year*	Lake Havasu		Softening Plant			
			Influent		Effluent	
	Alpha	Beta-gamma	Alpha	Beta-gamma	Alpha	Beta-gamma
Average activity— $\mu\text{mc/l}$						
1952-53	3.4	7.7	5.8	8.5	5.9	7.7
1953-54	3.6	9.9	5.2	9.8	5.0	9.2
1954-55	3.2	21.9	4.0	12.9	4.1	8.7
1955-56	3.7	10.7	3.8	12.4	3.3	9.5
1956-57	4.3	19.7	4.6	19.4	4.8	17.0
1957-	4.2	22.1	4.7	18.8	4.1	15.1

* Jul. 1 to Jun. 30.

River water as received at the softening plant is not subject to the short-term changes in chemical quality observed in samples from Lake Havasu.

Biological Monitoring

Changes in biological quality of the water, particularly with regard to plankton population, are more likely to occur within relatively short periods of time. Samples for microscopic examination are collected semimonthly from Lake Havasu, Gene Reservoir, and Copper Basin Reservoir, and rec-

ing of the growths. Because of this practice, a general treatment of the lake has not been required since 1951.

Occasionally growths may appear in Lake Mathews in less than significant numbers and yet cause difficulty in filter operation at the plant. Under these circumstances coagulation is used to condition the water before filtration. This procedure is also adopted if growths develop suddenly and are carried into the plant with the influent water before spot treatment can be applied, or if clay or other fine insoluble

matter is washed into the reservoir during storm runoff and substantially increases the turbidity of the water.

Water samples for bacteriological examination are taken daily from the treatment plant influent. Although Colorado River water is protected from human pollution throughout the aqueduct system and is, therefore, of comparatively good sanitary quality, coliform organisms are introduced into the water by birds in the Lake Mathews area. As a result, almost 10 per cent of the sampling tubes of plant influent water show the presence of coliform organisms. After treatment at the softening and filtration plant, however, the water is of excellent bacteriological quality. Of the more than 30,000 bacteriological tubes planted with treatment plant effluent water samples collected during the 17 years of plant operation, only eleven have shown positive results in the completed test for coliform organisms. For the same period, more than 500,000 tubes planted with samples of treated water collected in the distribution system have yielded only 502 in which coliform organisms were found.

Radiological Monitoring

With the advent of the atomic age, the possibility of radioactive contamination of water supplies led the district to institute a program of assaying radioactivity in Colorado River water in the Lake Mead and Lake Havasu watershed areas and along the route of the aqueduct. In cooperation with the Los Angeles Department of Water and Power and the California Disaster Office, 53 permanent soil-sampling stations were established in the area surrounding the Nevada proving ground of the AEC. Surveys were made prior

to the first weapons tests in January 1951 in order to obtain basic data on natural radioactivity of soils in the vicinity of Lake Mead. To evaluate changes due to fallout, resurveys were made in 1952, 1953, and 1955. The data indicated that soils showing evidence of contamination were generally north of Lake Mead and in an area extending eastward toward the Virgin River watershed.

Water samples from Lake Mead and Lake Havasu are examined monthly for radioactivity. At the treatment plant, similar radioactivity assays are made on the monthly composite samples of plant influent and effluent waters. The data in Table 1 represent the annual average levels of radioactivity in Colorado River water at Lake Havasu and in the treatment plant influent and effluent waters. It will be noted that the principal increase in radioactivity occurred in 1957. This might be attributed to the increased frequency of tests with megaton fission-fusion weapons by the major military powers or to the radioactivity caused by rain bringing down fission products accumulated in the stratosphere. To date, the gross beta-gamma activity in Colorado River water has remained well below the maximum peacetime permissible level of 100 $\mu\text{mc}/\text{l}$; no measurable change in alpha activity has occurred as a result of the fallout. It appears, however, that in the future water supply agencies must become more conscious of the possibility of contamination of water by radioactive waste products resulting from peacetime uses of nuclear energy and radioisotopes. With the facilities available at the district's treatment plant, this type of contamination too can be reduced to a safe level in Colorado River water.

Single-Rubber-Gasket Joints for Cast-Iron Pressure Pipe

—Thomas F. Wolfe—

A contribution to the Journal by Thomas F. Wolfe, Managing Director, Cast Iron Pipe Research Assn., Chicago, Ill. Adapted from a paper presented on Sep. 20, 1957, at the Ohio Section Meeting, Cincinnati, Ohio.

ONE of the greatest advances in the water distribution field in recent years has resulted from the development of single-rubber-gasket joints for cast-iron pipe. A brief review of the evolution of cast-iron pipe joints reveals the advantages of these new joints.

The first satisfactory joint for cast-iron pressure pipe was developed in 1785 by Thomas Simpson, an engineer for the Chelsea Water Co., London. This joint was known as the bell-and-spigot joint, and was made by slipping the spigot end of a pipe into a pipe with a belled-out end. Oakum, or similar material, was then driven in against a shoulder at the innermost part of the bell, and virgin pig lead was poured in back of the oakum. This lead was calked or hammered to form a tight, compact, metallic joint. An alternate way of making this joint, developed later, was to pour in sulfur compounds and allow them to set. Calking was not necessary. Bell-and-spigot joints in which neat cement is calked into the space behind the packing material have been used extensively in the western and southwestern United States.

Mechanical Joints

The bell-and-spigot joint was standard in the cast-iron pipe industry

throughout the world until the middle 1920's. This joint was eminently satisfactory for water use, but the gas industry wanted a tighter joint. During the middle 1920's, the different manufacturers developed various types of mechanical-joint pipes for the gas industry. The makers of these joints used the "stuffing box" principle, in which a rubber gasket was compressed by drawing up a gland into the bell recess by the use of bolts and nuts. Unlike the bell-and-spigot joint, the mechanical joint could be deflected after it was put in service and still remain water- and gas-tight. It was, therefore, no longer necessary to provide lead-melting equipment, ladles, calking tools, or joint runners, which were cumbersome to move as the job progressed. The mechanical joint required only one or two ratchet wrenches to make up the joint. Another advantage of the mechanical-joint pipe was that it could be laid under wet-trench conditions. This could not be done with hot-lead, sulfur-compound, or cement joints.

The water industry also became interested in the mechanical-joint pipe because of its greater deflection, ability to be installed under wet-trench conditions, and easier assembly procedures. The mechanical joint won acceptance

very rapidly, aided in part by regulations of some state health departments which forbade the use of jute-packed joints where the jute would be in contact with water. Since then, less bell-and-spigot pipe and more mechanical-joint pipe has been used. Until recently, 75-85 per cent of all cast-iron pipe sold in the United States had mechanical joints.

At first, each company had its own particular design for mechanical-joint pipe. When the use of this pipe in-

A rubber gasket under compression offers resistance to the flow of fluids under pressure.

A modified design of the bell-and-spigot joint is used for the roll-on joint. A round, rubber gasket is placed on the plain end of the pipe. This end is then inserted into a special bell in which the opening is tapered to assist in rolling the gasket under a restriction ring and into the back section of the bell against a shoulder. The gasket is compressed to approximately 50 per cent

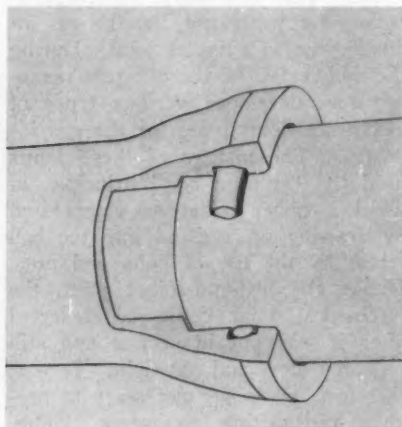


Fig. 1. Altite Joint Pipe Assembly

This pipe joint was developed by the Alabama Pipe Co., Anniston, Ala.

creased, however, the cast-iron pipe industry adopted, in 1942, a standardized mechanical joint to be manufactured by all producers (1).

Roll-on Joints

In the 1930's the cast-iron pipe industry developed the roll-on joint. This joint offered a considerable saving, as compared with the mechanical joint. The roll-on joint was a development from an old principle used in industrial equipment for sealing fluids:

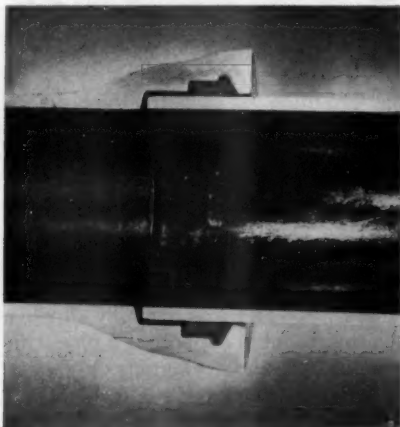


Fig. 2. Bell-Tite Joint Pipe Assembly

This pipe joint was developed by James B. Clow & Sons, Chicago, Ill. It is also manufactured by Lynchburg Foundry Co. and Lone Star Steel Co.

of normal diameter. A strand of braided jute is driven in behind the restriction ring and back of the rubber gasket. This serves to hold the gasket in position and confine it under compression. A bituminous mastic is then filled into the remaining annular space of the bell.

The roll-on, single-rubber-gasket joint was and still is a good joint for cast-iron water pipe. It offers economy

and a good degree of joint deflection. Under normal laying conditions, it still remains a very fine joint, and millions of feet of roll-on joint pipe have been laid throughout the United States. The roll-on joint, however, has some limitations. When laid in a wet trench, the rubber has a tendency to slide and twist rather than roll; laying is, therefore, largely limited to dry weather and trench conditions. In sizes of 12-in. diameter and larger, a machined groove on the spigot end of

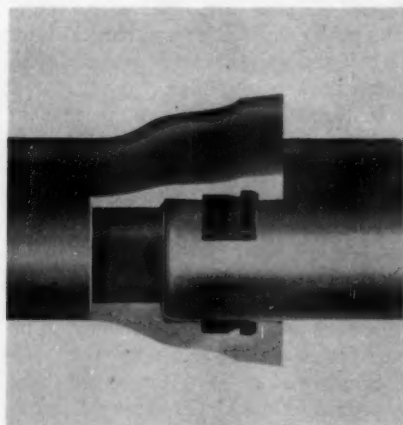


Fig. 3. Fastite Joint Pipe Assembly

This pipe joint was developed by the American Cast Iron Pipe Co., Birmingham, Ala.

this pipe is of considerable aid where wet-trench conditions are encountered.

Roll-on-joint pipe is manufactured in sizes ranging from 2 to 48 in. diameter. This pipe is classified by the Cast Iron Pipe Research Association (CIPRA), Specification 8-57; sizes from 4 to 12 in. diameter are covered by Federal Specification WW-P-421a as Joint Type No. II. All sizes are approved by Underwriters' Laboratories, Inc., New York.

Single-Rubber-Gasket Joints

Through the years, there were many patent applications for rubber-ring-single gaskets for joints for cast-iron pressure pipe. Recently one of the manufacturers of cast-iron pipe engineered and tested a joint which consisted of a modified design of the old bell-and-plain-end pipe joint. This joint consisted of a single, rubber ring which snapped into place and became locked in a groove inside the bell. By

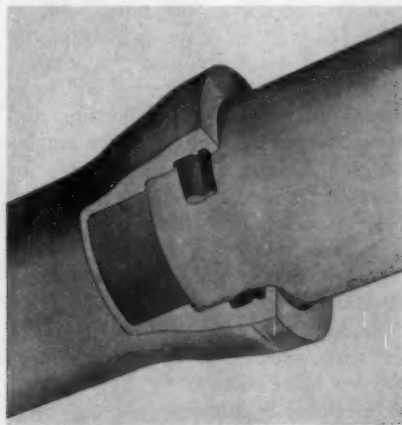


Fig. 4. Tyton Joint Pipe Assembly

This pipe joint was developed by the United States Pipe & Foundry Co., Birmingham, Ala. It is also manufactured by Glamorgan Pipe & Foundry Co., McWane Cast Iron Pipe Co., Pacific States Cast Iron Pipe Co., Shahmoom Industries, and R. D. Wood Co.

sliding the plain end of the pipe into the bell and through the lubricated rubber ring, the rubber gasket was compressed, and thus became pressure-tight.

As so often occurred in the early days of the mechanical pipe joint, each pipe manufacturer independently proceeded to design and manufacture cast-iron water pipe with these new, single-

gasket joints. Today there are four types of single-rubber-gasket joints offered by the various domestic producers of cast-iron pressure pipe.* Each producer offers at least one of these types of joints. In general, the principle of all of these joints is the same. Variations are all in the design of the bell and the gasket, and the differing hardnesses, as measured by a durometer, of the rubber gaskets used.

Single-rubber-gasket joint pipe is produced in sizes ranging from 2 to 48 in. diameter. There are many advantages in using this pipe. All of these joints incorporate, in general, the features of simplicity, ease of assembly, joint tightness, self-centering and locking of the pipe, ample deflection, and decreased laying time, with the single-sealing element. Some features of these joints are:

1. Assembly of the single-gasket joint is simple, easy, and fast. Users report increases in installation rate of 50-100 per cent.

2. Assembly tools are furnished by the manufacturer, as required. Material for lubrication of the gasket prior to assembly is furnished in all cases.

3. Bell holes are not necessary for single-gasket-joint pipe, but are usually required for pipe with other types of joints.

4. The joints may be assembled under wet-trench conditions.

5. The joints allow a good degree of deflection.

6. The gaskets lock into place and will not roll on the spigot end of the pipe.

7. Pipes with single-gasket joints can be easily loaded or unloaded from railroad cars and trucks, and breakage is, therefore, reduced. There is less joint material to handle.

8. The OD of pipe with single-gasket joints is the same as that of mechanical- or bell-and-spigot-joint pipe. The plain ends of the different types of pipe are, therefore, interchangeable. Regular mechanical-joint or bell-and-spigot fittings are used with single-gasket-joint pipe.

9. Rubber gaskets are permanent and water-pressure-tight in mechanical, flanged, or single-gasket types of cast-iron pipe joint. By reducing the number of joint components, further service life has been added to the joint.

The result of all these advantages is that users of the single-gasket-joint pipe save time, labor, and money, at no sacrifice in quality and reliability.

Single-gasket joints have all been approved by the Underwriters' Laboratories for use with liquids at pressures up to 350 psi. Producers have tested all sizes of cast-iron pipe with single-gasket joints to destruction with pressures up to 3,000 psi. In most cases where the pipe was tested to destruction it was the pipe that failed rather than the joint.

*"Altite," manufactured by the Alabama Pipe Co., Anniston, Ala. (Fig. 1); "Bell-Tite," manufactured by James B. Clow & Sons, Chicago, Ill. (Fig. 2); "Fastite," manufactured by American Cast Iron Pipe Co., Birmingham, Ala. (Fig. 3); and "Tyton," manufactured by the United States Pipe & Foundry Co., Birmingham, Ala. (Fig. 4).

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1. American Standard for a Mechanical Joint for Cast Iron Pressure Pipe and Fittings—AWWA C111-53 (ASA A21.11-1953). Am. Wtr. Wks. Assn., New York (1953).

Stray-Current Problems Created by Modernizing Direct-Current Traction Lines

Hugh L. Hamilton

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by Hugh L. Hamilton, Pres., A. V. Smith Eng. Co., Narberth, Pa.

THE effects of electrolysis due to stray traction current on underground piping are familiar to operators of underground plants in communities where d-c traction systems exist, or have formerly existed. Most communities which have, or have had, d-c-operated traction systems have, in the relatively recent past, experienced sweeping changes in the system, as a result of modernization programs.

These modernization programs have generally fallen within one of the following categories:

1. Partial conversion from d-c-operated trolley cars to trackless trolleys and diesel-powered buses. All three types of conveyance may coexist.

2. Complete conversion from d-c-operated trolley cars to d-c-operated trackless trolleys and diesel-powered buses

3. Complete conversion from d-c-operated conveyances to a system consisting entirely of diesel-powered buses.

As a result of these programs, and the radical changes in the d-c traction system configuration they entail, a number of relatively new and very severe stray-current problems have been encountered. These problems are not necessarily new in an engineering sense, but their importance with re-

spect to corrosion of underground structures is new and warrants attention.

Many of the new problems are the direct results of the attempts by traction officials to achieve economies, without due regard for underground structures operated by other agencies. This is especially true in cases of partial conversion from d-c-operated conveyances, which result in a mixed system of trolley cars, trackless trolleys, and diesel-powered buses. In many cases, the use of both abandoned and operating trolley rails as negative return circuits has become so haphazard that the electrical circuits involved defy analysis.

There has been much speculation over the effect of these modernization programs on the corrosion of underground installations. Some sources are of the opinion that the reduction or complete elimination of d-c-operated conveyances will be beneficial to underground installations; others maintain that soil corrosion will proceed at accelerated rates in the absence of traction current. In any event, traction-system abandonment has lent impetus to the widespread use of cathodic protection. These cathodic protection arrangements often use abandoned rails, resulting in far-reaching interference

effects on neighboring structures. In many cases, the remaining stray traction-current effects have necessitated extreme degrees of cathodic protection.

Distance From Substation

Figure 1 illustrates a hypothetical traction system. The system in this

which exhibits inherent electrical resistance at the joints. It is, therefore, not suitable for natural or forced drainage of current, unless there is considerable additional work done in electrically bonding these joints.

Prior to abandonment of parts of the system, aggravated electrolysis failures occurred within a 2-3-block radius

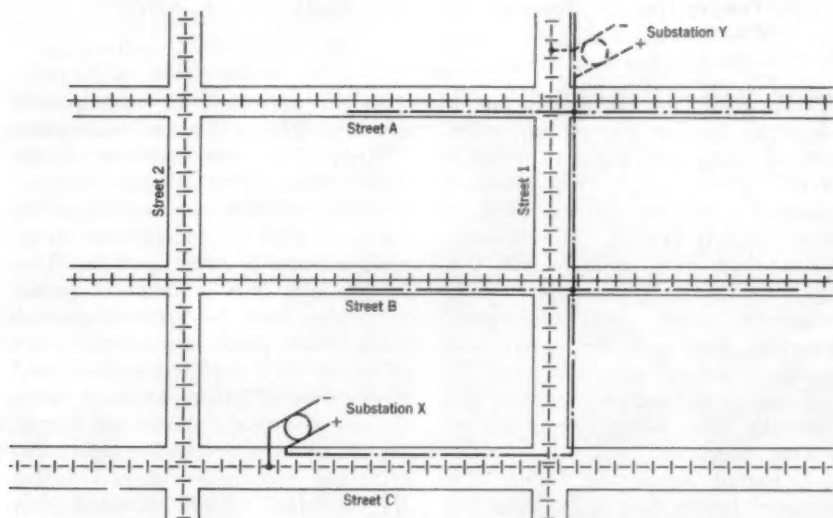


Fig. 1. Transit System, Partially Abandoned

This figure shows a hypothetical transit system. The rails on Streets 1, 2, and C (broken lines) have been abandoned, thereby discontinuing the maintenance program which preserved them as traction-current return circuits. The rails on Streets A and B (solid lines) are still being used. The distance from Street A to Street C is approximately 2.0 mi.

case consists of the traction-system Substations X and Y and a grid of trolley rails. Prior to the modernization program, all of the rails in this trolley grid were under an active maintenance program, which assured their integrity as a traction-current return circuit. The water distribution piping in the area is, hypothetically, of a type

of the substations on electrically undrained structures. With active rail maintenance throughout this system, failures in other areas were not excessive, and only normal maintenance was required for the underground plant.

As part of the modernization of this traction system, trolley routes were discontinued on Streets 1, 2, and C,

and Substation Y was taken out of operation. No additional metallic paths were installed for the return of current to Substation X, since it was assumed that the abandoned rails would continue to function as current carriers. Soon after, the abandoned trolley rails were paved over; as a result, all active maintenance on them had to cease.

Basic faults in the final configuration of this traction system could eventually create a serious electrolysis problem on underground installations in the entire area, rather than only in the relatively limited confines of the substations, as had previously been the case. Additional metallic paths should have been installed for returning current from operations on Street A to the Substation X. The number of additional metallic paths necessary could have been determined by an exact network analysis, using an allowable voltage drop from Street A to Substation X as the controlling condition.

The distance from Street C to Street A is approximately 2.0 mi. This, together with the use of abandoned and unmaintainable trolley rails as a primary traction-current return circuit, would cause extreme and uncontrollable stray-current flow on adjacent underground structures. These abandoned rails would, after a time, become ineffective as current carriers. To operate trolley cars properly on Street A from the Substation X would normally require additional conductivity for return current, after shutting down Substation Y. By using abandoned trolley rails as the primary return-current carriers, not only is the conductivity of the return path not increased as required, but it actually decreases as the unmaintained rails

become less conductive, due to breakage and loss of rail bondings.

Analysis of this problem shows that installation of sufficient additional negative feeders between Substation X and Substation Y is impossible from an economic standpoint. The answer lies in the fact that Substation Y should never have been closed down.

Operators of d-c traction systems in cities have an obligation to owners of underground plants adjacent to their system. In view of the congestion of underground structures in urban areas, d-c substations should be located relatively close together throughout the system, in order to avoid excessive stray traction-current flow on underground structures. Interurban traction systems are relatively free of this consideration, because of the much smaller density of underground plants adjacent to them. Shutting down Substation Y would amount, in this hypothetical case, to operating the traction system as an interurban line, but in a heavily congested urban area. This, plus the fact that existing duct space would not allow for the economical installation of sufficient additional copper feeders, indicates that shutting down Substation Y would be an unjustified action on the part of traction system operators in an urban area.

The possible effects of the condition illustrated by Fig. 1 on an underground plant are serious. The 20 lb/amp-yr figure for iron loss associated with stray-current electrolysis is well known. Obviously, the most complete answer to any electrolysis problem is to eliminate the stray traction current from the earth and, therefore, from the underground plant. The circumstances described can result in conditions exactly contrary to the ideal condition of complete elimination of stray currents.

To see exactly how this occurs, assume that a trolley car is operating on Street A. The operating current from this trolley flows out of the motor and onto the return circuit, consisting of the rails. For a given amount of current, there is a potential difference existing between the point where the trolley is located and the generator in

be thought of, for practical purposes, as the resistance of the rails to earth, since the actual electrical resistance of the earth path is negligible.) A simple parallel-circuit analysis will show that, as the resistance of the metallic path provided by the rails increases, due to breakage and lack of maintenance, the amount of current taking the earth path

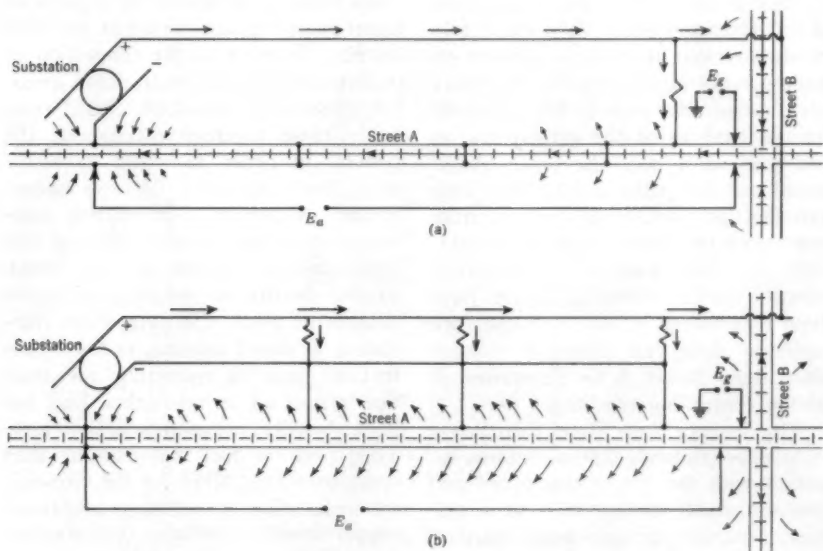


Fig. 2. Transit System, Before and After Partial Abandonment

Figure 2a represents a transit system in which stray current is kept within reasonable limits. In Fig. 2b, however, the rails on Street A have been abandoned. These abandoned rails will eventually become ground mats and transmit stray current into the earth.

Substation X, supplying the operating current. For this given amount of traction current, the potential difference varies directly with the resistance of the return path.

The return path consists of the metallic path provided by the rails, parallel with the path provided by the earth. (The resistance of the earth path may

increase proportionately. The result is that these rails, after a period of time, cease to act as current carriers, and begin, instead, to act as ground mats discharging current to the earth.

Use of Abandoned Rails

Figure 2a represents a well-maintained and properly designed traction

system. In this system, the rails are properly maintained, and are of sufficient conductivity to assure that the voltage drop E_a does not exceed a certain value for a given peak-current flow. This is the basic criterion for return-circuit conductance. Where trolley loads are such that the rails do not give sufficient conductivity, then additional negative feeders would be required to keep the value E_a within reasonable limits. By so controlling the value E_a , the amount of current discharged from the rails is limited, for as E_a is reduced so is the value E_g , which determines how much current is discharged to earth in a given configuration. As the electrical resistance of the rails increases, therefore, so does the value E_a for a given amount of current. As this occurs, E_g increases and more current is discharged to earth.

The traction system in Street A may, however, be abandoned, and the trolley rails paved over and thus made unmaintainable. The traction system in Street B, however, is to remain active, in this hypothetical case, and will be supplied by the same substation. No additional negative feeders are added; it is thought that the abandoned rails in Street A will function in this capacity.

As the rails in Street B become broken and electrically discontinuous, due to lack of maintenance, the resistance of the return path increases, and thus the value of E_a increases (Fig. 2b). This puts the rails in Street B at a correspondingly higher potential to earth; that is, E_g increases. The end result of the decay of these rails is to increase drastically the amount of traction current discharged to earth as the rails become electrically discontinuous.

Under this condition, no matter how well the rails of the active traction system in Street B are maintained, the severe electrolysis condition remains, because of the condition of the rails in Street A. The only solution is the installation of adequate negative-return cables from the substation to Street B. Adequacy of feeders is established by maintaining a reasonable voltage drop along the negative feeders between Street B and the substation.

Figure 2b depicts the effects of operating trackless trolleys with abandoned rails as negative feeders. This is accomplished by tapping the overhead negative trackless-trolley wire to the rails. When the abandoned rails are broken, as they eventually will be, they serve, not as current carriers, but as large ground mats discharging current to earth. Trackless-trolley current is shown in Fig. 2b as flowing through the resistance (motor) loads to the sections of broken rails, and from there to earth.

Formerly the distribution grid, with its inherent resistance to electrical flow, due to joint construction, had a limiting effect on traction current flowing on the structure; when the abandoned rails cannot serve as current carriers, this inherent resistance is not sufficient to limit the flow of traction current to a reasonable amount. Destructive quantities of current will, therefore, begin accumulating on the adjacent structures in the areas where the rails are discharging large amounts of current. This condition can lead to trouble areas, or "hot spots," at considerable distances from the substations, where these troubles were not previously encountered. The familiar pipe-joint corrosion will appear in areas where it never before existed, as a result of the high voltage gradients

set up across these relatively nonconductive joints. In the localized area of a broken rail the electrolysis conditions may be quite severe. This condition of a localized area of severe electrolysis conditions, caused by a broken trolley rail, is not a new problem. These rails may have been paved over,

The conditions illustrated by Fig. 1 and 2 were created by two types of transit-system operating condition brought about by revision of the systems. These two conditions—operating trolley lines at overextended distances from substations and use of abandoned rails as primary return—

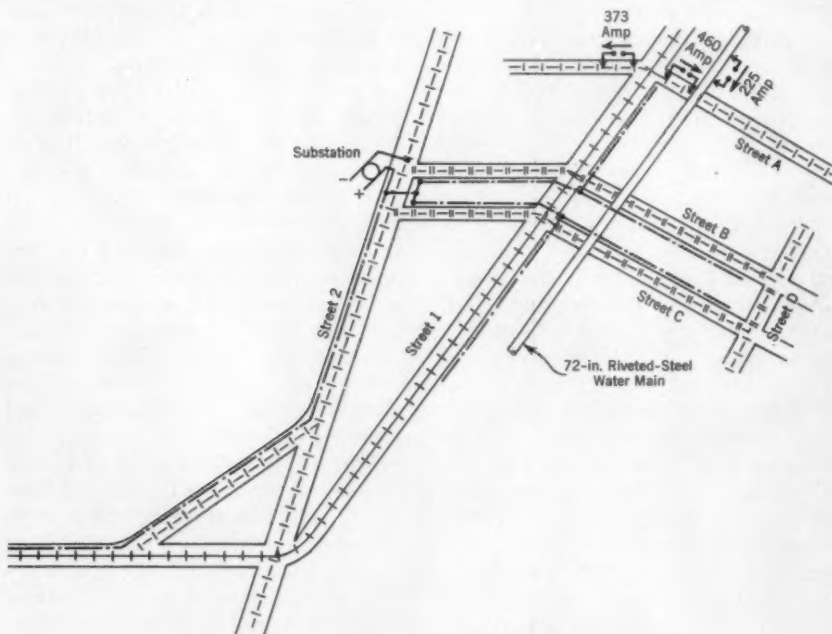


Fig. 3. Operating Transit System

This figure illustrates a transit system in operation at the present time. A trolley route (solid lines) operates on Street 1, and trackless trolleys operate on Streets B and C. Both types of trolley use abandoned rails (broken lines) as return-current feeders.

however, making detection and repair extremely difficult. Covering abandoned rails will constitute a new corrosion hazard, which will be a consequence of traction-system modernization programs which utilized abandoned rails.

current carriers—are basic causes of troubles to be expected when traction system revisions are not carried out properly, and with due regard for underground structures. These operating procedures not only create aggravated electrolysis conditions for an

underground plant; they also result in very poor operating efficiencies by the transit companies because of increased power losses in the return-current path.

Practical Effects

Figure 3 illustrates an actual traction system which has recently been modernized. The results of this modernization are similar to those described previously.

A trolley route is operating on Street 1, and a trackless-trolley route is operating on Streets B and C. Positive feeders extend from the substation to feed these routes. Abandoned trolley rails are used as the sole return-current conductors to the substation. The trackless trolley routes also utilize abandoned trolley rails as return-current feeders, a practice which is not uncommon when converting to trackless-trolley operation. The abandoned trolley rails in Streets B, C, and 2 are the only paths provided for the traction-system return current. The rails in these streets are paved over and inaccessible to even a basic maintenance program.

One of the effects of such operation on underground installations is shown in Fig. 3. A large, riveted-steel water-transmission main is placed roughly parallel to the traction system in Street 1. In the area of Street A, this structure is carrying peaks of 225 amp of stray traction current. Natural drainage of this current to the negative-return system in Streets B and C is impossible, because of the complete loss of conductivity of the abandoned rails in these two streets. These rails are running at such a high positive voltage to earth that current flow over a mitigation bond would be predominantly from rails to water main, de-

spite the excessive amounts of current already flowing on the main.

Electrolysis conditions in this area are becoming progressively worse, as a result of poor traction-system operational procedures, in spite of the fact that a large portion of the d-c traction system has been abandoned.

Further evidence of the effects of such operation in creating a heavy flow of traction current to earth and underground structures is shown in Fig. 3. The abandoned trolley rails in Street A remain electrically connected to the rails in Street 1, where an active trolley system is maintained. These abandoned rails conduct large amounts of traction current away from the active rails. This current eventually goes to earth, and, of course, to underground structures. A total of more than 800 amp of traction current flows to earth from these rails alone.

Unfortunately, effects of electrolysis due to these conditions do not occur immediately. There is some time lapse before abandoned rails used as return-current carriers lose their electrical conductivity. In addition, the large amount of traction current which is discharged from rails is generally spread over a relatively large area, except for some localized conditions. As a result, it may be several years after traction-system changes take place before failures will occur as a direct result. In this period of time, however, severe metal loss is occurring on the affected structures, and their ultimate destruction is inevitable, under the conditions described.

Other Corrosion Causes

The two factors discussed—operation of traction systems at extended distances from substations and use of

abandoned trolley rails as primary return-current carriers—are basic causes of severe electrolysis problems in areas previously free of them. Other factors, however, also created by traction-system revisions, can cause accelerated corrosion rates on underground structures.

One such factor arises from the conversion of trolley routes to trackless-trolley operation. Often the abandoned trolley rails along these new trackless routes are utilized as primary return-current carriers. This is accomplished by merely installing taps between rails and the overhead negative trolley wire. As it is related to electrolysis, this type of operation is the same as operating trolley cars on tracks. Since the rails used as return-current carriers are paved over and not maintained, the electrolysis condition is actually made worse by this method of operating trackless trolleys.

Another problem which may arise as a result of the partial abandonment of trolley systems can best be explained by referring again to Fig. 1. At some time during the history of a traction system, electrolysis conditions in the areas of the substations may have been so severe that drainage cables between rails and pipes were installed in these areas. It is not unusual for transit company operators themselves to have installed such drainage cables in substation areas. In the case illustrated by Fig. 1, if such drainage connections existed in the area of Substation Y, and Substation Y were taken out of service, the traction-system rails and the pipes to which the drainage cables were connected would be at essentially the same electrical potential to earth. This would mean that both pipe and

rails would be discharging large amounts of traction current to earth in this area. Old electrolysis bonds in the areas of abandoned traction-system substations should be removed, especially if the traction system still utilizes d-c-operated conveyances and utilizes rails as part of the return circuit.

When old electrolysis bonds exist in areas of abandoned traction-system substations, a similar condition may exist where operators of other structures in the area previously obtained beneficial drainage of stray traction current into the substation. As a result of shutting down the substation, this natural drainage of stray traction current is lost, and forced drainage systems are utilized for continued protection of these structures. These forced drainage systems in many cases are installed by utilizing the same terminals across which the drainage bond was connected. This type of installation makes the trolley rails the anode in the cathodic-protection system, and includes the pipe and the rails as part of the sacrificial anode when old electrolysis bonds between pipe and rail exist. There is, of course, an electrolysis bond between the pipe and the rail.

This is not meant to condemn the use of cathodic-protection rectifiers, which are effective in the mitigation of corrosion. The point to be brought out is, that where a rectifier installation is to be made to abandoned rails in areas where old electrolysis bonds may exist, the electrolysis bonds must be removed, in addition to the normal checks for interference effects from operation of the rectifier.

It is important to realize that in areas still containing some grounded, return, d-c traction systems, the stray,

traction-current voltage gradients in the earth may be of sufficient magnitude to mask the effects of rectifier test current on foreign structures. This may occur even when the pipes are made part of the anodes through the presence of old electrolysis-mitigation cables between abandoned rails and the structure.

The presence of old electrolysis bonds connected to a large grid of rails could, conceivably, lead to the flow of galvanic currents, which might adversely affect underground piping. As a general rule, removal of all electrolysis bonds between pipe and rails in areas where traction-system substations have been abandoned is a good practice. This will preclude any of the aforementioned possibilities of accelerated corrosion rates.

Cathodic Protection

Cathodic protection has been accepted as an effective means of combating corrosion on underground structures. As this principle becomes more widely accepted, cathodic protection installations will continue to grow in number. Whether or not an operator of a water system subscribes to the use of cathodic protection on his own structure, this structure may still suffer accelerated electrolysis damage as a result of cathodic protection systems installed on neighboring properties. This may be avoided if such cathodic protection systems are properly designed, or adverse effects are properly mitigated, or both.

Revision and abandonment of transit systems may create the necessity for operators of neighboring underground structures to install cathodic protection systems. For many years underground

power and telephone cables have received valuable protection from soil corrosion through the drainage of traction current into traction-system substations. In localities where all d-c-operated conveyances have been abandoned, beneficial drainage of stray traction current will, in most cases, be supplanted by the installation of cathodic protection rectifiers for mitigation of soil corrosion. Stray or interference current from such rectifiers causes the same rate of corrosion when it flows on foreign structures as does stray traction current. In addition, in the case of cathodic-protection rectifier installations, the flow of interference current is constant and exhibits no mitigating variations in values, as is the case in most stray traction-current effects.

It is the obligation of the engineer designing a cathodic protection system for a structure either to design the system so that foreign structures are not adversely affected, or to compensate for adverse effects, or both. Unfortunately, these precautions are not always taken when installing a rectifier, either because of neglect on the part of the party installing the cathodic protection system, or because of failure on the part of owners of the structures affected to supply necessary information. It should be realized that such disinterest with regard to one rectifier installation may preclude any further inquiries regarding future installations.

Rectifier installations made without proper notification, or without regard for neighboring structures, are unfortunate. Such installations emphasize the importance of electrolysis committees, or other such organizations, whose one major function is to notify member

utilities and set up cooperative tests when such installations are made. Success of these committees is entirely dependent on the continuing interest and participation of all utilities in the area covered by the committee.

Conclusion

This article has covered the effects of changes in transit systems in creating and fostering relatively new stray-current problems on underground piping. In communities where more than half of the d-c traction system has been

abandoned, the stray traction-current problem not only can be made more severe, but can also manifest itself in areas where previously no major problem existed, unless proper practices are followed by transit companies. The tremendous increase in the use of cathodic protection rectifiers, both as a result of the loss of beneficial drainage of traction current due to d-c traction system abandonment, and because the use of this method of corrosion control has become more generally accepted, requires the vigorous attention of water utility operators.



Cultivation, Morphology, and Classification of the Iron Bacteria

Ralph S. Wolfe

A paper presented on Mar. 27, 1958, at the Illinois Section Meeting, Chicago, Ill., by Ralph S. Wolfe, Assoc. Prof., Dept. of Bacteriology, Univ. of Illinois, Urbana, Ill.

ALTHOUGH the iron bacteria have been observed for well over 100 years, most of the observations have been based upon the forms which the organisms exhibit in nature, with little or no attempt to obtain the bacteria in pure culture. Thus, the same organism has been given different names by different workers and the same organism has been regarded as several different species by a single worker—all as a result of a lack of knowledge of the role played by the environment in modifying the appearance of the organism.

Examples of several types of iron bacteria as they appear in crude natural samples are shown in Fig. 1a-f, 2a, and 2b. The twisted stalk fragments of *Gallionella* are apparent (Fig. 1a, 1c, and 1d) as are fragments of filamentous iron bacteria (Fig. 1a and 1b) commonly referred to as *Crenothrix* or *Leptothrix*. Figure 1f pictures the organism described by Dorff (1) as *Nau-maniella*, and Fig. 1e presents the frequently observed amorphous deposit which may or may not be of biological origin. Pringsheim (2) has defined iron bacteria as those organisms which deposit iron in a morphologically defined way. The following discussion describes some attempts to cultivate these bacteria and presents an appraisal of their classification.

The twisted bands of ferric hydroxide now known as *Gallionella* were first observed in 1836. Although the name *Spirophyllum* was also applied to this organism, that of *Gallionella* is correctly retained. For the next 80 years, these twisted bands of ferric hydroxide were considered to be living organisms. It was not until 1924 that Cholodny (3) observed the bean-shaped bacterial cell at the end of the twisted stalk and further demonstrated that the stalk was nonliving. The cell's extremely fragile attachment to the stalk accounted for its not having been observed previously.

Cultivation of *Gallionella*

Several years ago, attempts to cultivate *Gallionella* were begun by the author. Ferrous sulfide was found to be a good source of reduced iron because, as a result of its low solubility, it was not oxidized rapidly in the test tubes and provided a continuous supply of ferrous ions. Continuous subculture of *Gallionella* was not possible with this medium unless a small amount of tap water was added (4). The factor which is present in natural water and required by *Gallionella* has now been found to be calcium.

The method of culture has been further improved by the use of screw cap tubes to confine the carbon dioxide added to the medium, and by combin-

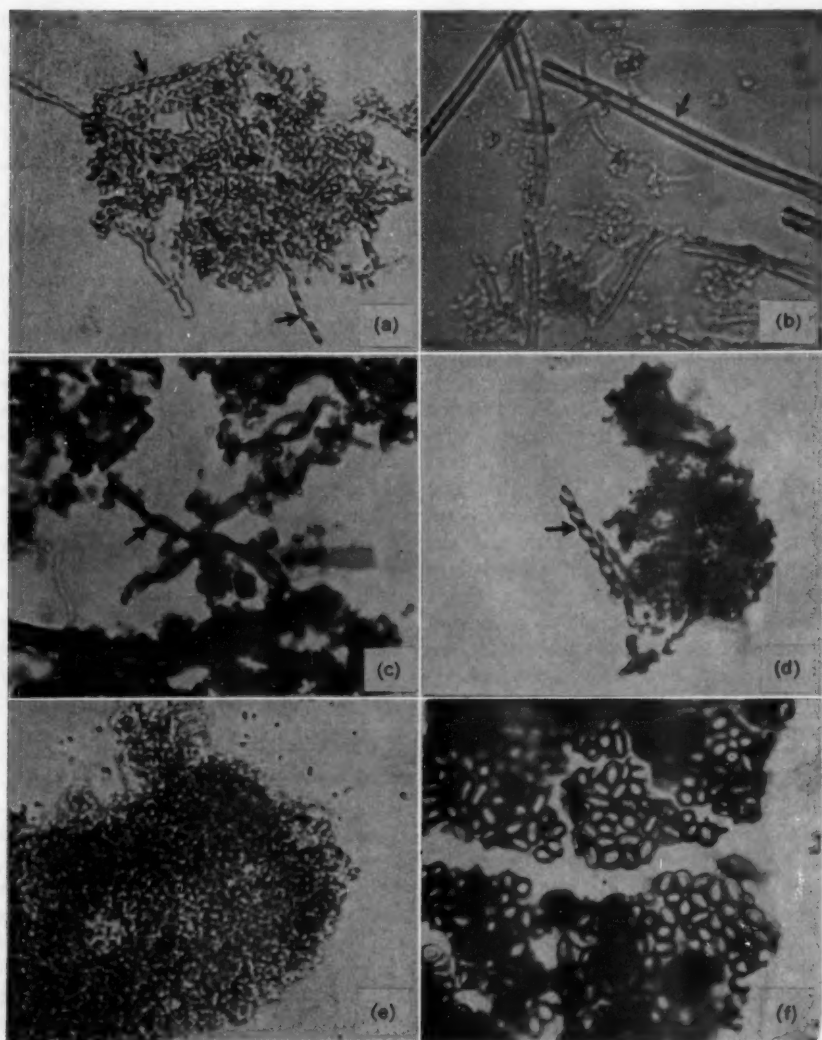


Fig. 1. Crude Natural Samples of Iron Bacteria

Mixtures of *Gallionella* stalks and amorphous precipitates are shown in Fig. 1a, 1c, and 1d at magnifications of $800\times$, $2,500\times$, and $1,500\times$ respectively. Figure 1b shows the hollow iron sheaths of *Sphaerotilus natans*, form *Leptothrix*, at $1,300\times$ magnification; Fig. 1e, an amorphous precipitate exhibiting the Prussian blue reaction—biological origin questionable—at $1,200\times$ magnification; and Fig. 1f, *Naumaniella* at $1,000\times$ magnification.

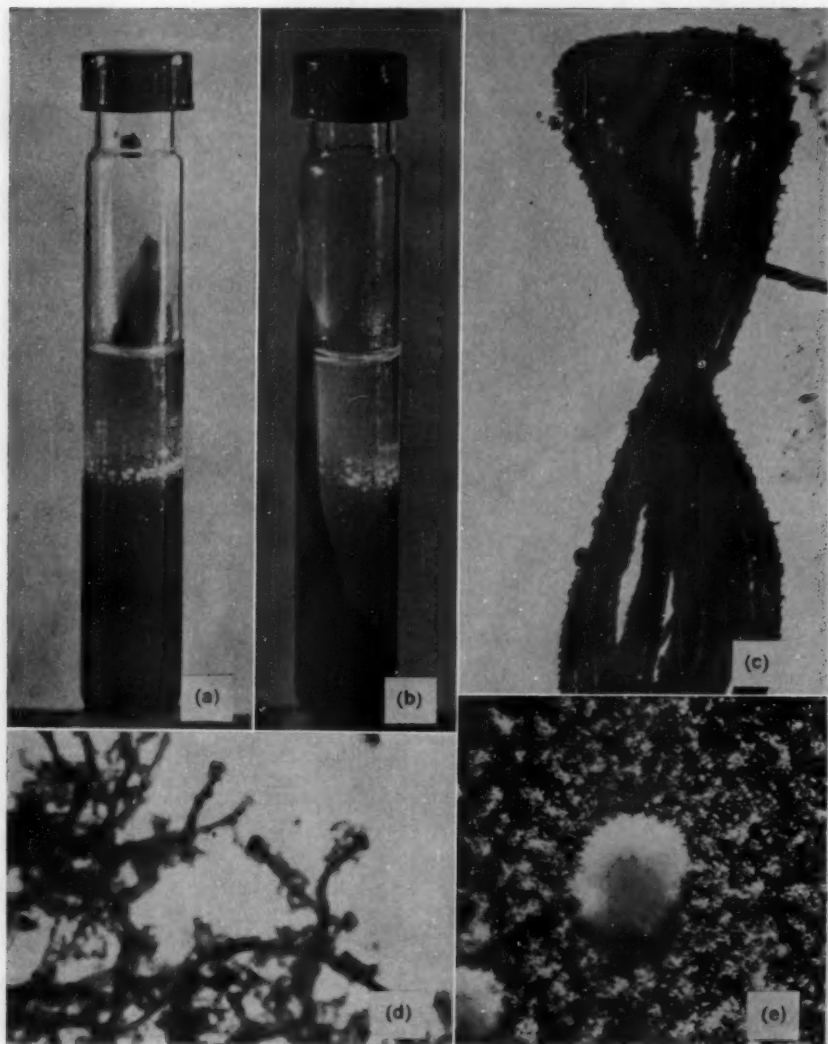


Fig. 2. *Gallionella ferruginea*

Front and side views of the culture tubes with colonies (about four-fifths actual size) are shown in Fig. 2a and 2b, with the ferrous sulfide-agar slant visible in the latter. Fig. 2c is an electron micrograph (17,500 \times) of the individual strands of the stalk with attached cell; Fig. 2d, a portion of a colony dried on a slide—at 2,500 \times —with the stalks stained by the Prussian blue reaction and the cells stained with crystal violet; and Fig. 2e, a mature colony showing young satellite growth (10 \times).

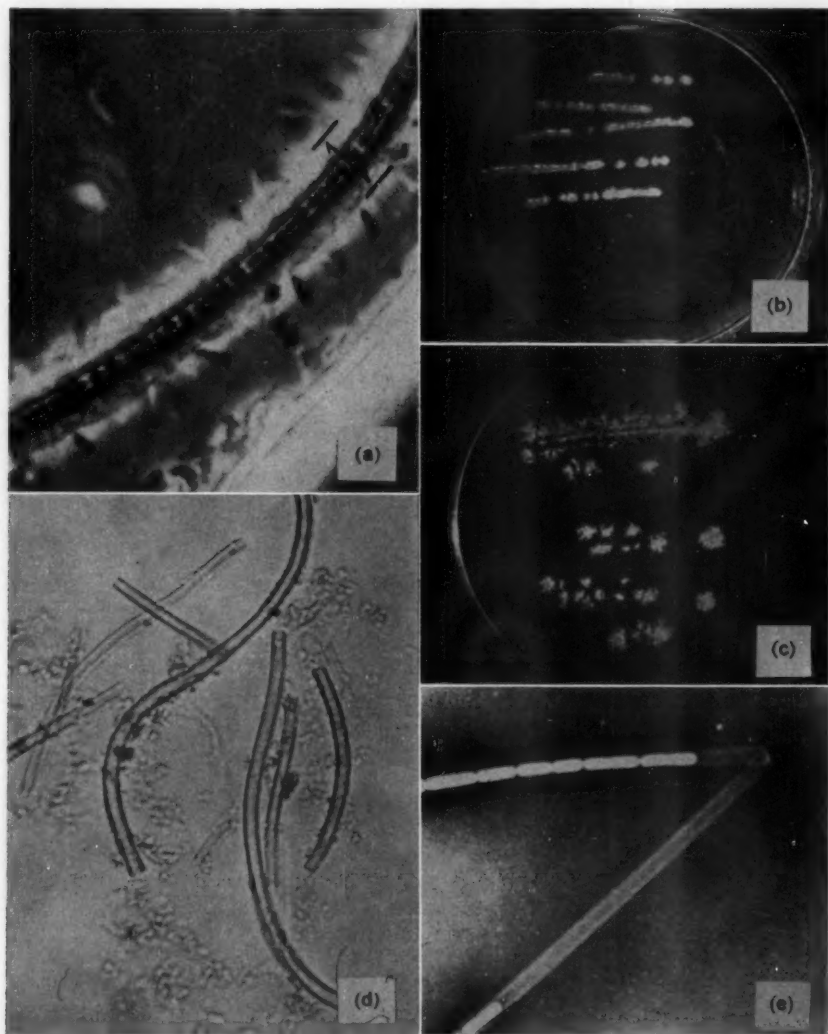


Fig. 3. Filamentous Iron Bacteria

Figure 3a is a phase contrast photomicrograph ($1,000\times$) of living cells of *Sphaerotilus discophorus*; Fig. 3b, smooth colonies of *Sphaerotilus natans* (about half size) on dilute yeast extract agar; Fig. 3c, rough colonies of *Sphaerotilus natans* (about half size); Fig. 3d, *Sphaerotilus natans*, form leptothrix, on natural material at $1,300\times$ magnification; Fig. 3e, *Sphaerotilus natans*, form eutrophica, nigrosin stained, showing sheath containing cells at $1,500\times$ magnification.

ing ferrous sulfide with agar and slanting before the liquid medium is added. The technique is as follows. Sterile ferrous sulfide precipitate—prepared as described above (4)—is mixed with an equal volume of sterile melted 3 per cent water agar at 45°C. This mixture is slanted in screw cap tubes. A liquid medium consisting of ammonium chloride, 1.0 g/l; dipotassium phosphate, 0.5 g/l; magnesium sulfate, 0.2 g/l; and calcium chloride, 0.1 g/l, is then added to the tubes. Carbon dioxide is bubbled through this medium for 10–15 sec before it is added to the test tubes. The tubes may then be inoculated with a drop of a suspension of a *Gallionella* deposit from a water main, aeration tray, filter bed, or other natural source. *Gallionella* grows well at room temperatures, and colonies usually appear in 18–36 hr after inoculation. The type of growth produced by this method is illustrated in Fig. 2a (front view) and Fig. 2b (side view). The white deposits on the sides of the test tubes are colonies of *Gallionella* which appear white because of light diffraction. The organism is sessile—that is, always growing attached to a solid object. The very definite ring of *Gallionella* colonies is noteworthy (Fig. 2a and 2b). This is the typical growth habit of the organisms in test tubes and seems logically explained as a result of an upward diffusion of ferrous ions and a downward diffusion of oxygen molecules. *Gallionella* will grow only at a position where an adequate supply of both ferrous ions and oxygen is present. Likewise, in nature, active deposits of *Gallionella* are found where the organism can compete effectively with the auto-oxidation of ferrous ions which, at neutral pH, is very rapid. In this culture method, a pH of about 6.6 allows best

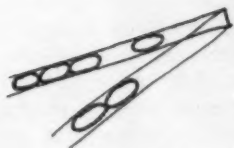
growth. Figure 2c presents a colony of *Gallionella* at a relatively high magnification that shows satellite growth which occurs around the mature colony as the culture ages.

By using extreme care it is possible to retain a few of the bean-shaped cells on the stalks during slide preparation (Fig. 2d). Here the stalks have been treated with ferrocyanide and dilute hydrochloric acid and so exhibit the Prussian blue reaction. The cells have been stained with crystal violet.

In the electron microscope, the stalks of *Gallionella* are found to be not composed of solid bands of ferric hydroxide, but rather of a number of separate strands (5). In Fig. 2c these individual strands are easily seen. Although an impression of a bow is given, this is actually a result of the spiral twist of the stalk.

There are no real problems in recognizing the twisted stalk fragments of *Gallionella* in water supply equipment or in cultivating the organism. Although four species have been described in the last 120 years, it is doubtful if the organism has ever been obtained in pure culture. Samples of water from California, New Jersey, Indiana, and Illinois studied by the author have all yielded cultures of *Gallionella* which are indistinguishable from each other. The method of culture described—an enrichment method—has not yielded pure cultures, a *Pseudomonas* contaminant persisting in small numbers under the minimal conditions of the method. Until the organism has been studied in pure culture and various species confirmed, it is certainly sensible to describe the stalk fragments in natural waters as *Gallionella ferruginea*. The organism is undoubtedly an autotroph which obtains its energy from oxidizing ferrous salts to ferric salts,

Form *eutrophica* (found in ponds and polluted streams)



Form *ochracea* (Found in water high in iron, this form has the following synonyms: *Leptothrix ochracea*, *Leptothrix major*, and *Chlamydothrix ochracea*.)



Form *dichotoma* (Found in water low in iron and organic substances, this form has the synonym *Cladothrix dichotoma*.)



Form *sideropus* (synonyms: *Chlamydothrix sideropus* and *Leptothrix sideropus*)



Form *fusca* (synonym: *Clonothrix fusca*)

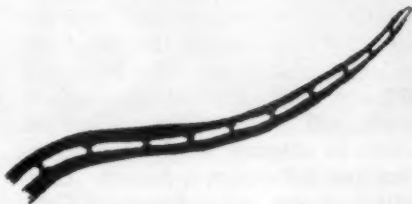


Fig. 4. *Sphaerotilus natans*

Forms shown are after Pringsheim.

its carbon from carbonates or carbon dioxide, and which synthesizes its proteins from ammonium chloride. It can, therefore, exist in waters devoid of organic matter. These factors have been discussed recently by Weart and Margrave (6).

Filamentous Iron Bacteria

In contrast to the definite morphology of *Gallionella*, the filamentous iron bacteria have been described by so many different names that a discussion of them becomes confused at the semantic level. Thus, the names *Crenothrix* and *Leptothrix* are in common use today, although, for reasons which will be presented, this usage is probably incorrect.

Typical examples of filamentous iron bacteria are shown in Fig. 1b and 3d. The rigid hollow tube shown turns blue when exposed to ferrocyanide and hydrochloric acid, indicating the presence of ferric ions. The structures are inert and may exist in nature for long periods of time, being easily recognized, for instance, in bog iron deposits. The names *Leptothrix* and *Crenothrix* are commonly applied to this morphological form although the tubes are non-living. Pringsheim (7) has shown convincingly that these tubes represent stages of advanced iron deposition in the sheaths of the filamentous bacterium *Sphaerotilus natans*. Although this organism is commonly associated with polluted streams and sewage rather than with water supply operations, Pringsheim's position is very strong. Employing pure cultures of *Sphaerotilus natans*, he was able to reproduce in the laboratory—merely by modifying the culture conditions—various types of iron bacteria found in nature.

Figure 3b shows smooth colonies of *Sphaerotilus natans* as they appear when grown on a dilute yeast extract medium and Fig. 3c shows them in their rough form. These figures are taken from an article by Stokes (8). Individual cells have motility produced by flagella, although they secrete a sheath inside of which the movement takes place. This sheath is comparable to a hollow cellophane tube. Figure 3e shows a nigrosin-stained preparation of *Sphaerotilus natans* which depicts a typical health containing cells. The sheath is almost invisible in a wet-mount preparation using ordinary light microscopy but is visible in a phase microscope or in stained mounts.

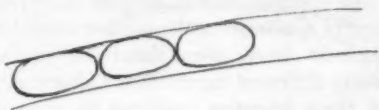
Thus, starting with pure cultures of this organism, Pringsheim was able to reproduce a variety of iron bacterial forms by varying the concentration of organic material, iron, and manganese. The deposition of iron in the sheaths has not been shown to be purely chemical, nor has it been shown to be biological. Some work done by the author indicates that it is doubtful if the organism actually utilizes the energy of iron oxidation, because iron deposition does not seem to be closely related to viability in *Sphaerotilus*.

Pringsheim (7) defines five forms of *Sphaerotilus natans* as shown in Fig. 4. Form *eutrophica* is the true form found in waters rich in organic material such as ponds, polluted streams, and sewage. The "iron pipe" form—*ochracea*—is found in waters containing iron. Synonyms for this form are: *Leptothrix ochracea*, *Leptothrix major*, and *Chlamydothrix ochracea*. In waters containing low organic matter and low iron the *dichotoma* form arises. This was described by Cohn as *Cladothrix dichotoma*. Under cer-

tain conditions of low iron, the *sideropus* form arises. This last has been described in the past as *Clonothrix fusca* but is actually a variant of *Sphaerotilus natans* in which iron is deposited, with the deposition thicker at the base and tapering off towards the growing end of the filament.

ward the growing end. It is difficult to reveal both the sheath and cells, but Fig. 3a—a photomicrograph made by phase contrast—shows the living cells surrounded by a very thick sheath to which are attached various rod-shaped bacteria. Figure 5 shows the various forms of this species, also described

Form *eutrophica* (Found in water rich in organic matter)



Form *manganifero* (Found in water low in organic matter and high in iron and manganese, this form has the synonyms *Megalothrix discophora* and *Leptothrix crassa*.)



Form *arachnoidea* (A fine cobweb-like growth not readily observed in nature.)

Form *ochraceoides* (Found in water low in manganese, high in iron, it is similar to the *Leptothrix* form of *Sphaerotilus natans* with sheaths less clearly outlined.)



Fig. 5. *Sphaerotilus discophorus*

Forms shown are after Pringsheim.

Another species of *Sphaerotilus* which is distinguished in waters containing manganese is *Sphaerotilus discophorus*. This is a delicate organism and may be identified by an uneven, wider sheath (10–20 μ as compared to 2–4 μ for *S. natans*), a sepia brown growth due to absorption of manganese, and a tapering of the sheath to-

ward the growing end, which are readily found in nature.

Crenothrix polyspora

The organism, *Crenothrix polyspora*, described by Cohn in 1870, should be considered. Its distinguishing characteristics are the large number of non-motile coccoid spores which it produces

and the gradual enlarging of the sheath at the end where the spores are discharged. The highly diagrammatic sketches of this organism are widely reproduced. It is doubtful, however, if the organism has been seriously observed since 1870; certainly it has never been cultivated. The name, *Crenothrix*, however, has been in common use for a long time to describe the *Leptothrix* form of *Sphaerotilus natans*. Pringsheim, Cholodny, Leisky, and many other workers have searched for the organism without success. The author has never seen it and would be most happy to receive samples which might be suspected to contain this organism. To be scientifically correct then, it seems advisable that the names *Crenothrix* and *Leptothrix* be discontinued and that *Sphaerotilus* be employed in their place.

Conclusions

Gallionella stalk fragments are easily recognized by their typical spiral twisting. The organism may be cultivated and continually subcultured by the method described, provided a small amount of calcium is furnished in addition to other constituents. Until the species of *Gallionella* have been obtained and studied in pure culture, it is sensible to record the stalk fragments commonly found in water supply plant equipment as *Gallionella ferruginea*.

The filamentous iron bacteria have been shown by Pringsheim to be forms of *Sphaerotilus natans* or *Sphaerotilus discophorus*. The organisms most

commonly found in water supply equipment represent forms of *S. natans*.

Acknowledgment

Figure 2d is from A. E. Vatter and R. S. Wolfe (5); Fig. 2e from Sonia Kucera and R. S. Wolfe (4); and Fig. 3b, c, and e from J. L. Stokes (8). Considerable credit is due to E. G. Pringsheim, who has patiently examined the filamentous bacteria and their relation to iron and manganese (7). The studies on the nutrition of *Gallionella* were supported by the National Science Foundation.

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Persistence of Combined Available Chlorine Residual in Gary-Hobart Distribution System

—Herbert L. Plowman Jr. and John M. Rademacher—

A paper presented on Feb. 6, 1958, at the Indiana Section Meeting, Indianapolis, Ind., by Herbert L. Plowman Jr., Chief Chemist, Gary-Hobart Water Corp., Gary, Ind., and John M. Rademacher, San. Engr., USPHS, Chicago, Ill.

MANY studies have been made on the structural, hydraulic, and biological characteristics of water utilities. The literature shows an abundance of data available in all of these areas (1, 2).

Little has been reported, however, in the way of data on the persistence of a combined available chlorine residual in a water distribution system. A combined available residual is known to be more stable than a free available residual, and many plants utilize post-chlorine-ammonia treatment to obtain stability and persistence of the residual throughout extended distribution systems. To investigate the effect of this type of residual on a distribution system, the Chicago regional office of the USPHS supplied personnel and equipment for such a study. In cooperation with the Division of Sanitary Engineering of the Indiana State Board of Health, a study was made at the Gary-Hobart Water Corp., Gary, Ind.

Through the use of portable chlorine residual recorders, it was felt that certain facets of the combined available chlorine residual in an extended distribution system could be investigated. It was the purpose of this study to utilize equipment of this type to determine:

1. The persistence of a combined available chlorine residual throughout a distribution system
2. The effect of water temperatures on a residual
3. Causes of the fluctuation in the residual
4. The utility of a chlorine residual recorder as a guide for more efficient chlorination
5. The utility of these recorders as a means of measuring times of flow from the plant to various points on the distribution system
6. The dependability of the recorders under a variety of operating conditions
7. The utility of a recorder as an indicator of sabotage with bacteriological agents.

Gary-Hobart System

For a test of this nature, an extended distribution system was necessary, to make it possible to observe extreme effects on the residual. The Gary-Hobart water system was ideal, as it possessed an extended distribution system, as illustrated by Fig. 1, and because it utilized post-chlorine-ammonia treatment. Pressure in the distribution system is maintained by

booster stations as well as elevated tanks.

The system's treatment plant takes its supply from Lake Michigan. The plant provides conventional chemical coagulation, rapid sand filtration with prechlorination, and a free available chlorine residual. Up to 60 mgd of water can be produced for distribution. Since all treatment and storage facilities are covered, no chlorine-residual loss due to sunlight is encountered.

Operating control of the chlorine residual through the plant is maintained on the basis of hourly 15-sec colorimetric comparisons (flash tests) on the premixed and prefiltered water. A minimum level of 0.35 ppm free available chlorine residual is maintained ahead of filtration. This level is above the recommended limits proposed by Butterfield (3) for effective bacteriological control at the existing pH's and contact times. No apparent breakpoint can be determined on the basis of chlorine-demand tests.

Postchlorination is provided ahead of the 2.5-mil gal clear well to maintain approximately a 1.0-ppm free available chlorine residual. Anhydrous ammonia is applied to the water leaving the plant at a chlorine-to-ammonia ratio of 3 to 1.

The pH of the raw water varies from 7.7 to 8.3, and the pH of the finished water from 7.3 to 7.6.

Procedure

In order to measure persistence, and other characteristics, of the free available chlorine residual, two portable chlorine residual recorders* were used. One was installed at the water-

treatment plant to record total chlorine residual of the water leaving the plant. The second recorder was installed at the locations and for the time periods shown in Table 1. Distances from the plant to the various recorder locations ranged from 3.7 to 9.5 mi. It was hoped that the chlorine residuals could thus be recorded through the entire range of water temperatures experienced at the Gary-Hobart supply.

Both recorders were checked once each day by laboratory personnel. The amperometric titrator procedure (4) was used to calibrate each recorder, and adjustments were made whenever indicated residual variations of more than 0.05 ppm occurred. Any unusual fluctuation on the recorded curve was noted and its cause determined, where possible.

Temperature records were obtained by the plant recorder on an hourly basis throughout the study. Initially, only daily readings of temperature could be made on the distribution recorder. Since considerable variations in temperature were observed at the Griffith installation (see Fig. 1 for the location of the installations described) in July, a continuous-recording thermometer† was obtained for use during the balance of the study.

The chlorine-residual data recorded on the charts and the temperatures were compared on the basis of daily averages. Using the amperometric titrator as the control, only those charts which recorded final residuals within ± 0.05 ppm of the daily titrator readings were included in the compilation. Local effects on the residual, which were not representative of the actual

* Manufactured by Wallace & Tiernan Inc., Belleville, N.J.

† Manufactured by the Taylor Instrument Co., Rochester, N.Y.

area conditions, were not included in the analysis. Data from the Miller elevated tank location fell into this category.

Residual Recorder Data

Maintenance of the residual recorder was not an important problem in these tests. Except for occasional water-

heavily traveled railroad, the vibration caused by passing trains was sufficient to break one of the wire connections, thus causing the short. One week, approximately, was required to locate and correct this condition.

1. *Treatment plant.* Initially, the recorder in the treatment plant was located in the laboratory. No attempt

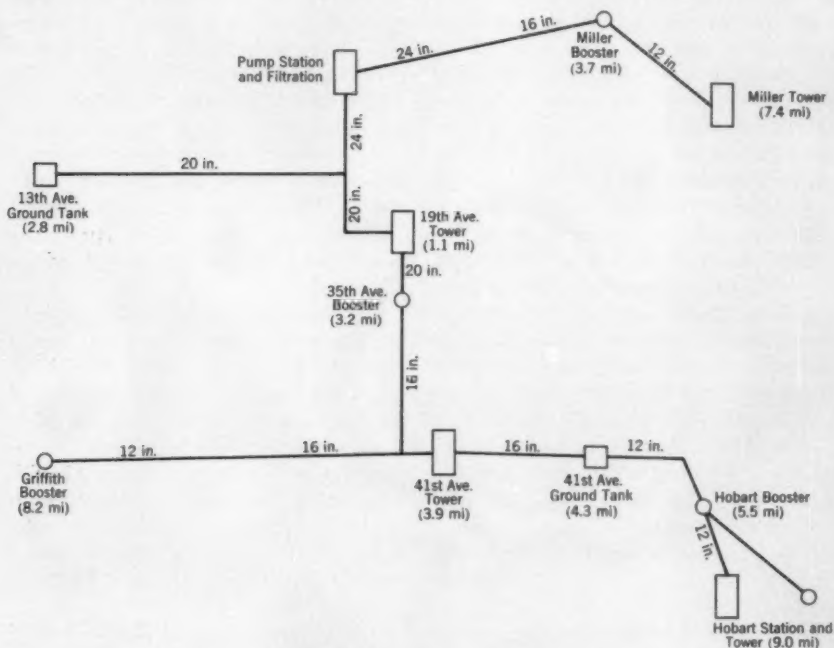


Fig. 1. Gary-Hobart Water Distribution System

The miles in parentheses indicate the water-main distance from the plant. The inches are the diameter of the water pipe indicated.

pressure drops and buffer-solution pump-tube replacements, the only recorder malfunction of major significance was an electrical short in the panel wiring of the distribution-system machine. Due to the proximity of the recorder location in Hobart to a

was made to control plant residuals with the recorder. Chlorination control by operating personnel was on the basis of the orthotolidine test.

It was apparent early in the study that regular, near-circular recorder curves were not a normal pattern of

operation. A representative recorder chart during this phase of the study had a somewhat "egg-shaped" curve. This reflected, primarily, the control exercised by the shift operators at the plant.

In order to compare the advantages of a chlorine dosage-control and a colorimetric standard operation, the recorder was relocated to the operating-room floor, and the shift operators were instructed to control the chlorine feed on the basis of the recorder curve. In a representative chart, after this control was instituted, residual variation for amounts up to 1.0 ppm was not more than ± 0.1 ppm. A comparison with the control range of 0.45-1.05 ppm illustrates the superiority of continuous recorder control over the intermittent colorimetric procedure.

Operational effects at the treatment plant upon the chlorine residual and the resultant fluctuations in the recorded curve were noted. The restriction of the high-service pump discharge, the starting or stopping of another high-service pump, or the sharp adjustment of the postchlorine dosage, all affected the residual and indicated that a short-circuit flow pattern existed in the 2.5-mil gal reservoir. Specifically, the postchlorine dosage adjustment showed that the flow-through time in the reservoir was only a matter of minutes, while on the basis of even a 30-mgd rate, the retention time should be at least 2.0 hr.

2. *Hobart installation.* At the Hobart installation, Apr. 11 through May 22, the recorder showed that residual losses were extremely low, with an average daily loss of between zero and 0.20 ppm. For this period the average combined available chlorine residual leaving the plant daily varied from

0.54 to 1.08 ppm, and averaged slightly more than 0.75 daily. Daily average residual at the Hobart installation varied from 0.52 to 0.95 ppm, and averaged slightly less than 0.70 ppm per day for the period. (Data for 4 days on which the recorded residuals were out of the control limits of ± 0.05 ppm are not included.) Average temperatures of the water leaving the plant during this period increased from 44 to 56°F. The daily temperature reading at the Hobart instrument reflected the same rise, although the Hobart temperatures

TABLE 1
Chlorine Residual Recorder Locations

Location*	Water-Main Distance From Plant mi	Dates Operated 1957
1. Hobart purification plant	9.0	Apr. 11-May 22
2. Miller elevated tank	7.4	May 23-Jun. 9
3. Miller pumping station	3.7	Jun. 10-Jul. 2
4. Old Griffith treatment plant	9.5	Jul. 3-Jul. 30
5. Hobart purification plant	9.0	Jul. 31-Sep. 12
6. Miller elevated tank	7.4	Sep. 13-Sep. 22
7. Miller pumping station	3.7	Sep. 23-Oct. 15
8. New Griffith pumping station	8.2	Oct. 16-Nov. 1

* See Fig. 1.

were normally 1-2°F higher than at the plant.

Although wide variations in the chlorine residual were recorded on the plant instrument, these were not reflected in the residual curves for the Hobart area. A leveling of the extremes was standard, and a fairly regular curve, varying approximately from 0.60 to 0.70 ppm, was the usual pattern. Mixing, occasioned by the storage facilities on the system and the flow patterns of the extended distribution system to Hobart, probably accounted for this condition.

Comparison of the total available chlorine residuals, as determined by the amperometric titrator and the orthotolidine-arsenite procedure, showed a consistent difference. The amperometric-titrator results were regularly 0.20–0.35 ppm higher than the colorimetric tests. On the basis of this observation, the chlorine residual leaving the plant was reduced from the 1.0–1.2 ppm level to a 0.6–0.8 ppm level. This not only resulted in a more economical operation, but the reduction in residual also afforded an opportunity to determine time of flow between the plant and the Hobart area using the recorder charts. This was found to be approximately 17–18 hr. Normally, the leveling action of the distribution system on the chlorine residual made an estimate of flow-time to the Hobart area impossible. The flow time of travel, as determined by the chlorine dosage drop, was confirmed at a later date, using fluoride as a tracer. A time lag of 24 hr was used to indicate distribution travel time and to compute the differences in average residuals. On the basis of sample calculations, using 12-, 18-, and 24-hr differentials, the 24-hr figure appears justified.

3. *Miller elevated tank and pumping station.* The recorder was installed in the pressure-control station at the Miller elevated tank site. Due to poor drainage facilities at this location, the recorder waste water flooded the station basement and, as a result, the recorder could only be installed for 2 weeks. A typical recorder chart revealed a high chlorine-demand pattern, which persisted throughout the test period at the tank. The peak residual of 0.7 and 0.8 ppm recorded on this chart reflected the 0.6–0.8 ppm level of

the residual leaving the plant. A comparison of the pumpage and pressure charts for the Miller pumping station with the residual patterns developed at the Miller tank revealed that the residual followed the pumping cycle with a time lag of approximately 1.5 hr, and that it appeared that the high demand was being created by the elevated tank.

The cause of the high demand in the tank was not determined, although sampling showed the water to be bacteriologically safe. A temporary relief was obtained by draining and refilling the tank on two occasions during the test period. After each refilling the minimum chlorine residual stayed above the 0.25 ppm level for 4 days.

Due to the flooding of the recorder site and the erratic nature of the chart patterns produced, the instrument was transferred to the Miller pumping station in order to obtain more representative system data for that area. The curves recorded at the pumping station reflected a 3–5 hr time of travel with respect to the plant operation. A typical recorder chart showed a curve varying from approximately 0.5 to 0.8 ppm. For the period of Jun. 10 through Jul. 2, the daily average residual for the treatment plant ranged from 0.56 to 1.03 ppm, and averaged slightly more than 0.70 ppm per day for the period. The daily average residual for the Miller station ranged from 0.51 to 1.03 ppm, and averaged slightly more than 0.65 ppm per day for the period. (Three days in which the recorded residuals were outside the control limit of ± 0.05 ppm are not included in these figures.) Temperatures at both Miller installations for

the period of May 23, through Jul. 1 ranged from 50 to 61°F.

The pattern of residual loss in the system for the overall temperature range (44–61°F) in this time period was narrow, and the magnitude of loss was not apparently affected by the variation in distance between the plant and the recorder locations studied (see Table 1).

4. *Old Griffith treatment plant.* The Old Griffith treatment plant did not prove very satisfactory from the study standpoint, since it reflected a local condition and did not represent the area under study. The data collected at this instrument location did, however, forecast the system-to-temperature effect on the chlorine residual. This effect was experienced, later in the study, by the entire distribution system. Although the recorder water supply was taken directly from the water main supplying the elevated tank at the recorder site, the flow pattern in the immediate area was apparently such that little water was actually used from the tank. This was borne out by the observation of the wide temperature difference between the Griffith installation and the plant. Since the average increase of the water temperature at the other distribution recorder locations was only 1–2°F, with respect to the plant discharge, the temperature increase ranging from 6 to 15°F at the Griffith site probably was the result of heat transfer in the elevated tank. For the period of Jul. 2 through Jul. 29, the daily average residual of the treatment plant ranged from 0.56 to 0.94 ppm, and averaged almost 0.80 ppm per day for the period. The daily average residual of the Old Griffith plant ranged from 0.08 to 0.25 ppm, and

averaged slightly more than 0.15 ppm per day for the period. (Three days in which the recorded residuals were outside the control limits of ± 0.05 ppm are not included in these figures.)

During the period of the Griffith installation the lake-water temperature increased rapidly. A 9°F rise was recorded in the plant data for Jul. 23–24. This demonstrated the dropping of the thermocline (a temperature gradient which marks sharp changes) past the intake structure. Within a day or two after this date, the water temperature maintained a range of 68–74°F until Sep. 20–22, when it dropped from 71 to 63°F.

For the balance of the study, from Jul. 30 through Nov. 1, the distribution system recorder was again located at the same sites, with the exception of the Griffith plant. To obtain better data for the Griffith area, the recorder was located at the newly completed Griffith pumping station for the period of Oct 15 through Nov. 1. As was expected, the residuals recorded at this location compared with those for the Miller and Hobart sites.

5. *Residual variation and temperatures.* During the warm-water period (Jul. 30 through Sep. 12, temperature 68–73°F) the daily average residual of the treatment plant ranged from 0.60 to 1.06 ppm, and averaged slightly less than 1.00 ppm per day for the period. The daily average residual of the Hobart station ranged from 0.15 to 0.37 ppm, and averaged about 0.25 ppm per day for the period. (Eleven days in which there was machine malfunction or the control limits were exceeded are not included in these figures. Part of this malfunction was the short-circuit mentioned previously, which incapaci-

tated the Hobart recorder Aug. 22 through Aug. 26.)

During the cool-water period (Sep. 24 through Oct. 15, temperature 58–66°F) the average daily residual of the treatment plant ranged from 1.01 to 1.25 ppm, and averaged slightly less than 1.20 ppm daily. The residual of the Miller station ranged from 0.82 to 1.21 ppm, and averaged about 1.05 ppm daily.

Figure 2 summarizes the data of the residual recorders. This graph indicates a high residual loss at temperatures greater than 65°F. Although the

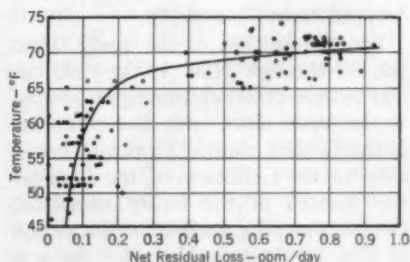


Fig. 2. Temperature and Chlorine Residual Loss

The trend curve was drawn from the averages of the net residual losses at various temperatures.

losses were not as sharply delineated, this trend was also observed in laboratory work on the bactericidal efficiency of combined available chlorine treatment in Chicago (5).

Laboratory Verification

To investigate the apparent critical-temperature range (60–75°F) more closely, an attempt was made in the laboratory to hold the water for 18–24 hr at each degree increment of temperature and determine the residual loss. For this purpose a 30-in. length

of 4-in. cast-iron pipe, which had been in use in the Gary distribution system, was blank-flanged at both ends and taps were made for inlet, outlet, and temperature-recorder connections. On the inlet to the test section, a pressure gage and external-type water-heating unit were installed, and a temperature recorder was connected at the outlet end of the test section. The flow-control valve was located on the discharge pipe for the system. The test section was fully insulated, and the whole system was sterilized. The water supply for the test unit was piped directly from a laboratory tap to the heating unit.

With this system, it was possible to maintain the temperature of the water within a $\pm 0.5^\circ\text{F}$ range for $2\frac{1}{2}$ –3 hr. This was far short of the necessary 18–24 hr period. Time requirements and physical facilities prevented any further effort to obtain a more adequate control. Some information, which followed the trend curve (Fig. 2) was obtained by using this information, however. An example, which is representative of these observations, showed a loss of residual of 0.37 ppm in $2\frac{1}{2}$ hr at 69°F, while losses of only 0.05 ppm were measured at 63°F for the same time period.

In order to determine the possible reason for high losses of residual during periods of warm water, a check for postoxidative effect in the water was made. Samples were collected in dark, glass bottles from the plant tap. The initial combined available chlorine residual varied between 0.90 and 1.05 ppm on all samples collected for this purpose. The samples were tightly capped and stored in a dark cabinet for 24 hr. The residuals were rechecked at the end of the holding period. The

loss in residual was not more than 0.10–0.20 ppm for any of the samples checked. It would appear that the postoxidative effect was negligible and that the demand is created within the distribution system.

Observations by distribution system personnel revealed that only a slight discoloration in the water was visible when hydrants were flushed, and that no slimy deposits were apparent on the pipe interiors when the occasion arose to cut into an existing main.

No direct evidence is available to prove the existence or absence of a high-demand, aftergrowth-producing organism such as, for example, nitrosomonas. Nevertheless, the recorder data and laboratory work indicate that a high order of chlorine demand exists in the distribution system and that it may not be of an organic nature.

Summary

On the basis of the observations of the chlorine residual patterns developed during the study, the persistence of the combined available chlorine residual has been demonstrated. It was apparent that even in an extended distribution system, such as Gary-Hobart, a residual can be maintained, although local and other effects may modify it greatly.

Perhaps the most significant factor observed during the study was the extreme loss of chlorine residual in the system with only a 3–5°F rise in water temperature above 65°F. On the other hand, residuals recorded at the distribution system locations showed that little or no loss of residual is encountered during those times of the year when the water temperature is below 65°F. This facet should be explored more fully to determine the ex-

act nature of the demand and whether this is common to other systems utilizing postchlorine-ammonia treatment.

Primarily, fluctuations in the residual at the treatment plant were attributed to short-circuit flow patterns in the 2.5-mil gal reservoir. It would seem that more attention should be given to reservoir inlet and outlet locations, and that there should be baffling to provide a proper flow pattern through the reservoir.

The residual pattern developed at the Miller elevated tank reflects a necessity to clean, sterilize, and possibly paint this facility. Since routine orthotolidine-arsenite checks at the elevated tank have been performed in the past, it is very likely that without the recorder this pattern would not have been noticeable.

Based on the premise that a uniform residual leaving the treatment plant is desirable, the superiority of control afforded by the use of the recorder was evident. This is in addition to the advantages of having a continuous record of chlorine residual, and of effecting some economy in chlorine feed through more efficient dosage control.

Although time of flow in a distribution system can be measured by means of the residual recorders, the leveling of the residual in the more extended portions of the distribution system makes accurate determination difficult and impractical.

In view of the amount of handling involved in the various moves from location to location, the portable recorders operated very satisfactorily. Without them, a study of this type would not have been feasible. The use of equipment of this type predicates a routine daily maintenance check and a complete understanding of the

operation of the unit by the servicing personnel involved. A recorder could be used to determine normal patterns of the chlorine residual in the distribution system, and it would be feasible to spot these instruments in critical locations so that any sabotage effort with bacteriological agents would be apparent and could be detected immediately.

It is evident that further investigation is needed to understand fully the relationship between the distribution system and the chlorine residual carried by the water.

Acknowledgments

Sincere appreciation is expressed to:

Leo Louis, vice-president and general manager, Gary-Hobart Water Corp., Gary, Ind., through whose offices the study was made possible; G. G. Fassnacht, Indiana State Board of Health, Indianapolis, Ind.; H. W. Poston, USPHS, Chicago; and D. H. Howells, USPHS, Washington, D.C., for their support and guidance; and Keith Young, assistant chemist, Gary-Hobart Water Corp., Gary, Ind., for

his able maintenance of the equipment.

In addition, the authors wish to thank the Gary-Hobart water works operating staff; the Taylor Instrument Co., Rochester, N.Y., for the use of the temperature-recording instrument; and those members of Wallace & Tiernan Inc., Belleville, N.J., who contributed time and advice to the progress of the study.

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Use of Liquid Alum at Richmond, Va.

H. E. Lordley

A paper presented on Nov. 6, 1957, at the Virginia Section Meeting, Roanoke, Va., by H. E. Lordley, Asst. Director, Dept. of Public Utilities, Richmond, Va.

THE Richmond, Va., Department of Public Utilities is a self-sustaining operation of the city, and its rates must be sufficient to cover operating costs, interest on debt, and capital improvements. With the increased cost of materials and labor every effort is made to reduce operating costs through the use of mechanical equipment, new products, and methods. One of the outstanding examples of cost reduction has been the savings in the use of liquid alum in place of dry, rice grind alum.

In the early spring of 1956, it was learned that a liquid alum plant under construction at Hopewell, Va., would be producing alum in April 1956. As Hopewell is only 23 mi from Richmond, it appeared feasible to use liquid alum, and a preliminary estimate of savings compared to capital costs of a feeding plant was prepared. It was estimated that the department would pay for the additional facilities in less than 2 years from the savings in alum costs, so it proceeded with the design of storage and feeding facilities.

Installation of Facilities

The rated capacity of the plant is 66 mgd, with a maximum operating capacity of 88 mgd. Storage was designed for 7-day operations at the maximum capacity. The original purification plant, constructed in 1924, had a concrete wash water tank 28 × 43 × 11

ft, with a water capacity of 100,000 gal. In the new plant, filters are washed with the aerator pump, so minor piping changes were made to use the same method in the 1924 plant and make the wash water tank available for alum storage.

The engineering section prepared plans for a lead lining in the tank, using 10 lb lead on the bottom and up the sides to a height of 9 ft, to give a storage capacity of 73,000 gal of 8.3 per cent alum. A 3-in. rubber-lined steel filler pipe was constructed from the unloading platform to an overhead discharge into the storage tank, and 1½-in. lead pipe connects the tank to meters in each plant. The meters are calibrated to read in percentages at a specific gravity of 1.355. The discharge from the meters goes into the existing dissolving chamber of the dry-chemical feeder for dilution before the coagulant is applied to the raw water.

The entire liquid alum system was designed to feed by gravity with a head of approximately 10 ft on the meters. The only pumping required is from the tank truck to the storage tank, a height of 23 ft. The truck driver connects the rubber discharge hose to the city's filler pipe connection and, using the pump on his truck, transfers 3,200 gal alum to the storage tank in 30 min (Fig. 1). Provisions were made for flushing feed lines and

cleaning the meters, if sediment should offer any operating problems.

Bids were taken on the project, and a contract was awarded to a company specializing in lead burning. The installation was placed in operation on Sep. 28, 1956. Only two additions have been made to the facilities—a

essary to clean the meter tube and stainless-steel strainer only one time. The feed line has been flushed three times, so maintenance problems are nonexistent. The total cost of conversion was \$20,000, which has been written off the books in 13 months by savings.



Fig. 1. Pumping Liquid Alum at Richmond, Va.

Alum is transferred directly from the tank truck to the storage tanks, from which it is fed by gravity flow.

cover constructed by nailing asbestos sheets to 2 × 4-in. lumber to reduce acid fumes above the tank and a home-made plastic-bottle float to gage the tank.

Results

During 12 months of operation using liquid alum, the chemical has been excellent in quality, and it has been nec-

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1. Elimination of the dust problem
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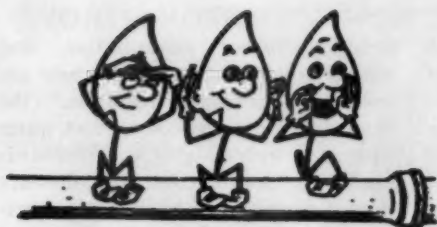
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Percolation and Runoff

"All the Water You Need, When and Where You Need It!" is a slogan we've rather neglected of late in the process of urging water workers to "Do It Now" to provide "improved water service, through water works systems self-sustained and adequate to meet the growing needs of each community." Actually, of course, we've merely been selling the same merchandise under a different label, for all three of these expressions have the same goal of putting water utilities in a position to give the public the kind of service it wants and can afford—the only means through which water works men will ever receive recognition, both tangible and intangible, commensurate with their contribution.

Toward the goal of adequate water supplies, many long steps have been taken of late. Two, representative of particularly high stepping, have been given prominent attention in the press. One of these was taken in New Jersey, where, with legislation authorizing the construction of 66 bil gal of storage reservoirs on the books and a \$45,-850,000 bond referendum due in November, a citizens' committee undertook an intensive campaign to assure that the voters will, this time, know what they are voting for. Headed by

the president of one of the nation's largest insurance companies, the committee has a statewide membership of citizens from all fields, and volunteers have been busy since June setting up speakers' bureaus, broadcasting radio appeals, sending out publicity of all types, and conducting mass meetings—giving some promise that now, after more than 25 years of trying, the state may at last be able to move ahead in the further development of its water resources. Meanwhile, in Michigan, as reported in August P&R (p. 48) the Southeastern Michigan Water Authority was giving detailed consideration to a project for supplying Lake Huron water to the cities of Detroit, Flint, and Pontiac, as well as to other urban and suburban areas in that part of the state. Consulting with engineering and investment firms, as well as with the officials of the municipalities concerned, the authority is planning a \$200,000,000 project if all three of the big cities involved join in. And even if all three do not join, the authority predicts that Detroit alone, or a combination of Flint and Pontiac, can make the project feasible.

Much persuasion, negotiation, engineering, and investment—not to mention construction—remain to be accomplished before Round Valley, Spruce

(Continued on page 48 P&R)

(Continued from page 47 P&R)

Run, or Lake Huron water begins to flow from New Jersey or southeastern Michigan taps, of course, but these proposals are manifestations of an approach that can make "all the water you need" a lot more feasible than if it must be sought on an individual-community basis only. Notably through independent authorities or districts, municipalities have, in pooling their resources, been able not only to develop otherwise unavailable supplies, but to divorce their water utility operations from local politics, to offer managerial and engineering jobs attractive to the best qualified personnel, and to apply the latest and most efficient techniques to operating and maintenance procedures.

Strictly from the viewpoint of providing water service that is adequate in quantity and quality, it seems not only desirable but necessary for communities to attack cooperatively those problems they cannot solve individually. As the public comes more and more to demand that water service be looked at strictly from the viewpoint of water service, it appears that the cooperative approach is bound to spread. And once the public demands and gets all the water it needs, when and where it needs it, water works men should at last be in line for all the recognition they deserve, when and where they deserve it.

You should live so long!

Monitored become monitor is the story of a new part that water is playing in the atomic age. Long monitored for radioactivity, water itself is now being used as a monitor—that is, as a sensing medium in a new gamma radiation detector said to be particularly applicable for monitoring such high-intensity radiation as used in food pres-

ervation, rubber vulcanization, and nuclear reactors. Basis of the new detector is "Cerenkov radiation," the blue-white glow that comes from water when it is under high-speed bombardment. An electronic eye some distance from a container of plain water intercepts the glow and converts it to electricity, the current then becoming a measure of the gamma radiation. What with the AEC now financing a hunt for new industrial uses of radioisotopes and encouraging industry to build new reactors, water seems scheduled to play an increasingly important part in radioactivity detection. Lest you get concerned, however, we should predict that long before water utilities have to consider increasing their capacity to meet the demands of this new use, Cerenkov, not to mention water works men, will have been radiated to a crisp. Even without a Merrimac.

Water and radioactivity may be interrelated in another way, too. Radioactive waste products of nuclear power reactors could be used in water and sewage plants to effect a 99 per cent reduction in harmful bacteria, according to research conducted at the University of Michigan by Professors Gerald M. Ridenour and Edward H. Armbruster of the School of Public Health. Not only would the technique find a use for radioactive wastes that now present a storage problem, but utility plant operating costs would be lessened. The method involved would be to cause the water (or sewage) to flow past a core of radioactive waste products, which would act like a powerful X-ray machine, killing the bacteria but not making the water radioactive. The core material would not need replacement for several years.

(Continued on page 50 P&R)

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(Continued from page 48 P&R)

Almost 800,000 water systems installed in 1 year—a growth of 1,500 per cent in 23 years—is the record established by the electric water system industry in 1955. To be exact, the total then was 796,332, compared with 764,105 in 1956 and 726,046 in 1957—well over 2,000,000 systems in just 3 years. It wouldn't mean much to compare that number with the cumulative total of 18,000 public water systems that was reached in the US in 1957, but what probably does rate comparison is the amount of money spent on public and private water system construction. Last year, for instance, each private system would have had to cost only \$770 to bring the total expenditure on such systems up to the public water

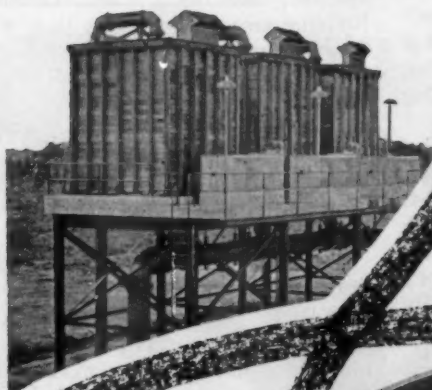
system 1957 total of \$560,000,000, and with motel, filling station, and other business systems involved in the private system total, there is no question that that would be a conservative figure. Inasmuch as public water systems serve approximately two-thirds of the population, this comparison undoubtedly points to the fact that private water systems are expensive—even extravagant—but there are two other points, too, that should not be missed: First, people are apparently willing to spend a considerable amount of money on water supply if they are convinced they must. Second, perhaps public water systems are not spending as much as they should on construction. Which is to say: **DO IT NOW!**



Odie E. Walker, vice-president, Mueller Co., Decatur, Ill., is shown being sworn in as adviser to the director of the Water & Sewerage Industry & Utilities Div., Business & Defense Services Administration, US Dept. of Commerce, by BDSA Administrator H. B. McCoy.

(Continued on page 52 P&R)

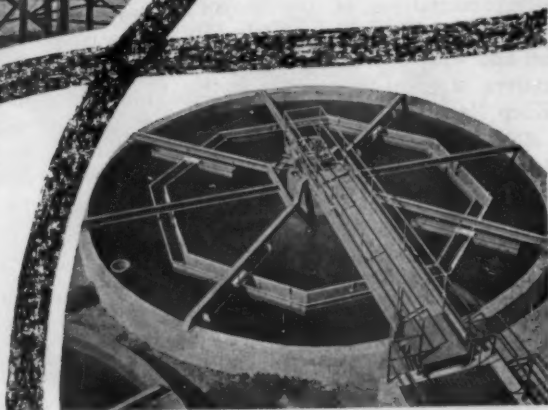
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(Continued from page 50 P&R)

A dog's life may soon become a dog's life in New York City if Sanitation Commissioner Paul Screvane's present plans are realized. Having pointed to New York's 272,000 licensed and other thousands of unlicensed dogs as "one of our more serious sanitation problems," the commissioner has just taken the first step toward ruling the fire hydrant out of bounds for canine comfort stops. His approach hasn't been that impolitic, of course, but it is no trick for an old dog to realize what the newly designed Screvane Dog Comfort Station is bound to mean.

The new "facility" is a glorified sandbox, 12 ft long and 4 ft wide, divided into two "runways" by a 4-ft wall, the top of which is planted with geraniums. Unveiled last month before representatives of the Mayor's Committee to Keep New York City Clean and what appeared to be representatives of the Canine's Committee to Keep New York City Comfortable, the station proved to be anything but that, its runways providing a 12-ft straightaway in the direction of the nearest hydrant. One of the basic troubles, of course, was Commissioner Screvane's unenlightened approach. To anyone who knows dogs it must be obvious that a comfort station, like a pipe, must be broken in before it is fit for use. Furthermore, as the *Wall Street Journal* properly pointed out, it takes no great imagination to see that "the average dog can hardly show its appreciation properly when geraniums are 4 ft off the ground."

Before the commissioner proceeds with mass production of his \$500 stations, he would undoubtedly be wise to undertake a little research into the canine psyche and into the techniques of true caninophiles in providing for the

comfort of their pets. Actually, we can recommend two field trips for this study: the new Bronx shelter of the American Society for the Prevention of Cruelty to Animals, where not only running water, soft music, indirect lighting, and community pens are featured, but outdoor play areas, each equipped with a New York City fire hydrant; and the Hudson Terminal Building arcade, in which a shop window displays a hydrant provided with partitioned enclosures around it and carrying the label, "Redesign of hydrant to insure canine privacy." This is the type of approach Mr. Screvane must take if he hopes to gain the co-operation of dogdom in obtaining controlled "facilitation."

Meanwhile, having read into the commissioner's statement (that failure would mean inside training for dogs) the possibility that his patience might not stretch quite far enough, we have at last found some advantage in the fact that New York City water customers are largely unmetered. Who else but the meter readers would suffer the reprisals?

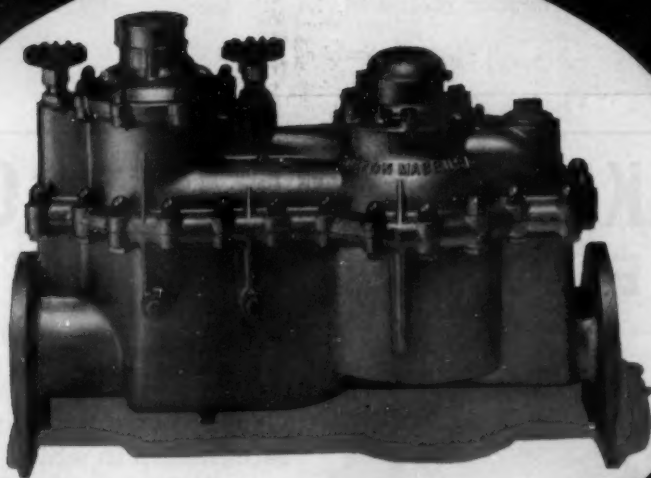
The firehouse is out, in Westville, Ill., these days—out of water, that is—meaning not only, as reported by United Press International, that "firemen have to take their engines to their homes to wash them," but that some mighty basic services there have had to be discontinued. Cause of the outage was nothing less than a shutoff for nonpayment of bills—bills that totaled \$6,566.85 by Jul. 1 for hydrant charges to the Westville Fire Protection Dist. The problem arose last year when the village water board increased the hydrant rate from \$27 to \$35 and the dis-

(Continued on page 54 P&R)

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(Continued from page 52 P&R)

trict just quit paying anything. Slow to burn, the water board took no action until this July, and then, of course, it cut off the supply only to the fire station itself, leaving the hydrants still ready to serve. No need to ask, what price conscience?

Earl Devendorf, director of the Bureau of Environmental Sanitation, New York State Health Dept., was presented with the Herman M. Biggs Award of the New York State Public Health Assn. in recognition of his outstanding work in the public health field, particularly with regard to water resources and pollution abatement. A member and former chairman of Orsanco and a member of Incodel, he



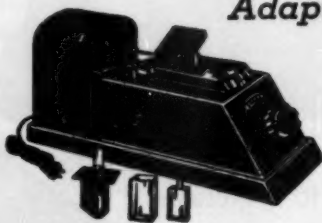
served as New York State water coordinator during World War II and the Korean War. He holds AWWA's Diven Medal and Fuller Award.

And now the symbol barrier, too, has yielded to the onslaught of science, the breakthrough having been achieved

(Continued on page 56 P&R)

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Slo-Mixer...Cross-Flow Flocculator...Vertical Flocculator...and Flash-Mixer. It clearly shows the advantages of Rex tank designs, and of Rex equipment to help you improve mixing, save chemicals, and increase plant efficiency.

Send for your copy today. Write to your Rex Sales Engineer, or to CHAIN Belt Company, 4609 West Greenfield Avenue, Milwaukee 1, Wisconsin.

CHAIN BELT

(Continued from page 54 P&R)

by the Remington Rand Univac Division staff in developing a "system," called "Flow-Matic," which "makes it possible to communicate with computers in the English language, instead of with mathematical symbols." Just how the system works, we're quite certain we wouldn't know if we were told. As to its advantages in electronic computing, we have no reason to doubt Remington Rand's claims of "faster and more accurate programing, easier programing analysis, better checking of systems design, the accomplishment of one-shot jobs formerly impractical, and greater flexibility." But what really excited us momentarily was the possibility that this system could help induce a return to "the English language." If, by "Flow-Matic," a Univac can be

"directed to accept descriptions of application requirements in the businessman's vocabulary and translate these descriptions automatically and accurately into detailed coded instructions," why couldn't "Flow-Matic" be made to insist on the use of good English, properly pronounced, as a prerequisite for accurate results?

But then, what's the use—how long can it be until the word barrier, too, succumbs? How long until a system, called "Psycho-Matic," reads the question in our mind and "Univac" flashes back the answer in a hunch? Meanwhile, if you have something to say to your computer, the "Flow-Matic" system of saying it is described in Manual U1518 obtainable from any Remington Rand office.

(Continued on page 58 P&R)

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**ELEVATED
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Complete Tank Service

Engineered and Erected According to
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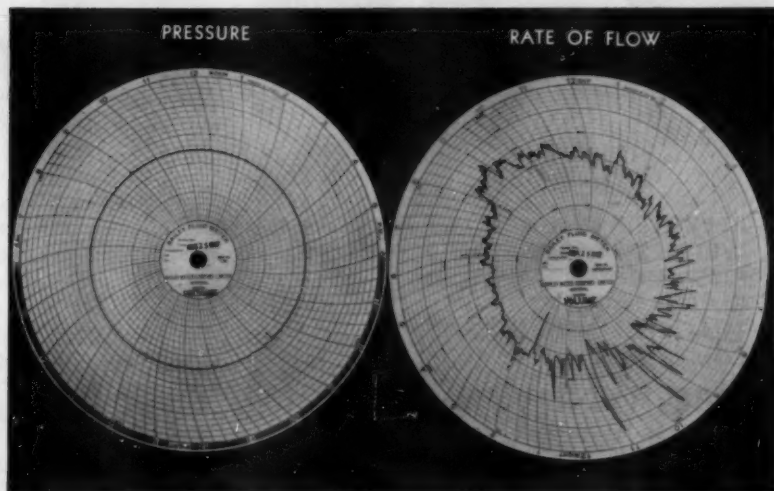
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Every hour of every day Edmonton, Alberta's waterworks maintains a constant water pressure... and BAILEY does it!

The Bailey Air-Operated Control System automatically regulates two 15,000,000 Imperial Gallon capacity, variable speed, high lift pumps each fitted with a hydraulic coupling...



Here are the Pressure and Rate of Flow records from one of these high lift pumps. Note what happened at 10:55 p.m. on August 25th... the flow increased 10.2 M.I.G.P.D. (67% of pump capacity) almost instantaneously, and there was a momentary drop in pressure of only 5 psi!

During the 24 hours when these charts were being recorded only one variable speed pump was in operation... and its output represented approximately 20% of the total plant output.

Every minute of every hour, Edmonton's water supply depends on BAILEY! W-7.5

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Founded 1854



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—with offices in principal cities of the United States.

(Continued from page 56 P&R)

A thirst that would lead a 170-lb man to drink more than 500 fifths per day of any liquid would undoubtedly be recognized anywhere as quite a thirst—and, if the liquid turned out to be water, quite the worst. That, however, is the rate at which a strain of mice now being studied by the USPHS drink our product, imbibing as much as five times their body weight per day—not, according to the studies, because “they have to drink,” but because “they just like to.” Bully for the mouse souses, we would say, were it not for the fact that almost 90 per cent of the males thereby drink themselves to death with a kidney and bladder disease called hydronephrosis. But bully anyway for the spouse mouse souses, who, reportedly, “are able to continue their heavy drinking with no apparent ill effects.” And bully, too, for the Public Health Service if it is successful in finding what makes the mice like water so much. Our fortune would be made!

The pool hall, these days, is usually the one that leads out into the backyard, where more and more people are now providing their own swimming facilities. As recently as 1955 there were only some 250 swimming pool manufacturers in the country and it wasn't many years before that that private pools were considered strictly Hollywood stuff. Now there are 2,000 builders expecting to put in 53,000 pools this year, and, at \$3,500, the average backyard pool is down to the price of the average little bigger than small car. This adds up to a lot of water, of course, almost 2 bil gal for the initial fill of the 1958 crop, but, as the water is usually circulated through filters and chlorinated, the makeup required is probably not much more than the lawn

(Continued on page 60 P&R)



the bigger your pumping problems

... the better your reasons for

giving them to

WHEELER-ECONOMY

You know how big problems can be, in selecting pumps for water works reservoir service. The Pumps you see here are specially designed and built to solve such problems. They're 36" Axial Flow Wheeler-Economy Pumps, each of which delivers 28,000 gpm. And they've been in continuous

service for many years with only routine maintenance and modest operating costs.

If you're puzzled over which pumps to use for water works, municipal or industrial power plant service, drainage, irrigation or flood control, see C. H. Wheeler. Your representative can help you even if you need capacities exceeding 220,000 gpm and heads of 75 feet. He'll give you expert advice on pump design and construction, and station arrangement suggestions you'll find helpful.

Economy Pump Division

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Whenever you see the name C. H. Wheeler on a product, you know it's a quality product

Centrifugal, Axial and Mixed Flow Pumps • Steam Condensers • Steam Jet Vacuum Equipment • Marine Auxiliary Machinery • Nuclear Products

1940-1955 CUMULATIVE INDEX TO THE JOURNAL

These features make the new 16-year Cumulative Index (clothbound, 192 pp.) a time-saving, easy-to-use guide to JOURNAL AWWA for 1940-1955:

- **topic index**—titles of all articles on a particular subject are listed together under the appropriate heading, with cross references to related topics.
- **geographic index**—lists names of places and areas dealt with by articles in detail.
- **author index**—provides a key to all articles by every author during the 16-year period covered.
- **other reference aids**—complete topical outline, alphabetical list of subjects, table of text page numbers for each issue.

List price, \$4.50

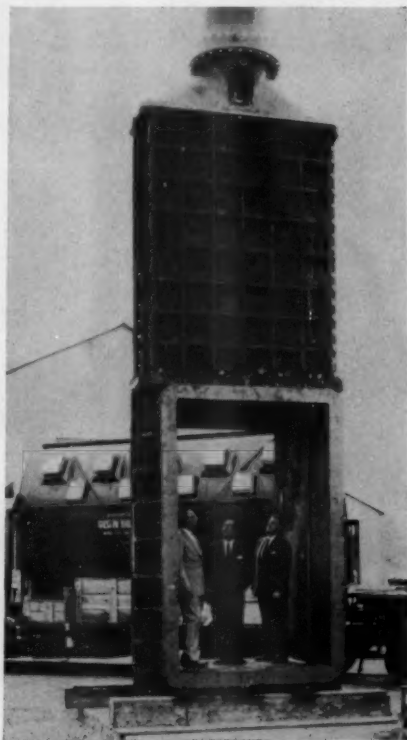
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WORKS ASSOCIATION**

2 Park Ave., New York 16, N. Y.

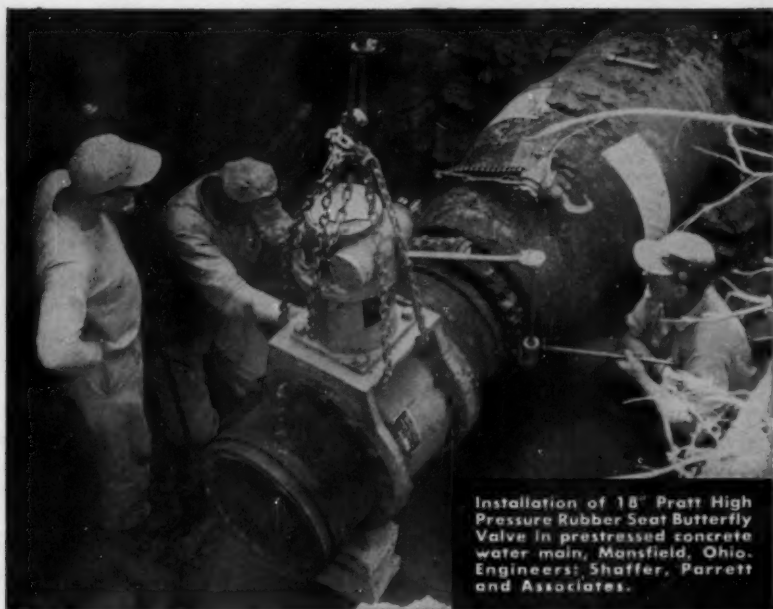
(Continued from page 58 P&R)

area replaced by the pool would usually consume during the peak use periods. And by making customers appreciate not only the recreational value of water but some of the problems of treating it, pools undoubtedly make better customers. As a matter of fact, right about now—in mid-July—*SPLASH!*



Three fearless executives of Commercial Credit Co. and its wholly owned subsidiary, Goslin-Birmingham Mfg. Co., inspect a 105,000-lb sluice gate made by the latter for installation in Ball Mountain Dam at Brattleboro, Vt. The gate has an overall height of more than 39 ft and a fluid way 6 by 10 ft.

(Continued on page 62 P&R)



Installation of 18" Pratt High Pressure Rubber Seat Butterfly Valve in prestressed concrete water main, Mansfield, Ohio. Engineers: Shaffer, Parrett and Associates.

MANSFIELD...Pratt Butterfly Valves meet all specs for distribution service

The real test of a distribution valve is its ability to operate when needed. Valves in water distribution service are primarily emergency measures, normally left either open or closed for months, or even years. Yet, they must operate when needed, often to prevent serious property damage in the event of a broken water main.

Mansfield engineers chose Pratt High Pressure Rubber Seat Butterfly Valves for this rigorous duty because Pratt valves meet all specifications for distribution service. The critical disc edge is a corrosion-resistant material, seating against a heavy, mechanically retained rubber liner to provide permanent, drop-tight shutoff. The stainless steel valve shaft rotates in bronze bearings, self-lubricated for life, and the valve operator is

permanently lubricated and sealed. These features are your assurance of easy operation when you need it... features that are built into Pratt valves with the experience that comes with 30 years of leadership in butterfly valve design. Specifying Pratt valves puts this experience to work for you.

NEW! Latest, most accurate pressure drop and flow data, conversion tables, discussion of butterfly valve theory and application plus other technical information.

Write for Manual B-26.



HENRY
PRATT

RUBBER SEAT
Butterfly Valves

Henry Pratt Company, 2222 S. Halsted St., Chicago 8, Ill. Representatives in principal cities

(Continued from page 60 P&R)

L. E. Ordeltjeide, formerly Missouri state sanitary engineer and most recently executive director of the Metropolitan St. Louis Sewer Dist., has become a member of the consulting firm of Haskins, Riddle & Sharp, Kansas City, Mo.

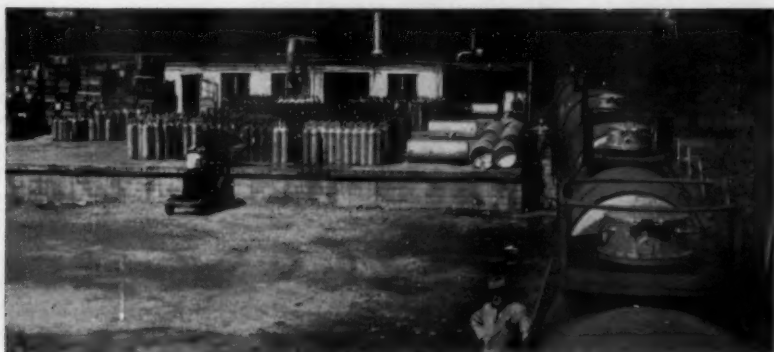
All isn't necessarily well that ends well, it seems: At Tulsa, Okla., for instance, George Sharp, drilling for water, had to contend with neighbors and ooze, when he struck oil instead. Being of strong mind—and thirsty—George drilled on, and finally did strike water 200 ft below. Then in Hay River, N.W.T., the community tried drilling for a new water supply and hit natural gas in three different holes—finally abandoning the search in fear of striking a real producer. They will probably have to draw water from Great Slave Lake, on the south shore of which the community is located, but 500 mi north of Edmonton, surface water is likely to freeze. Finally, at Onida, S.D., the city did

strike water—500,000 gpd—when it went prospecting for some 3 years ago, but for the past 2 years the 2,200-ft artesian well which it drilled has been flowing uncontrolled and all measures to plug it have failed. Unfortunately, the water, which is threatening now to undermine a federal highway, cannot be used, and the one 90-gpm well the city has in operation does not meet summer demands. Wethinks they drill, not wisely, but too well!

An elongated tricycle, equipped with a strong light and with semi-reclining seats for two full-grown men, one to steer and one to pedal, is what inspectors of the 100 mi of 36-in. pipe for use in a water line between Stuttgart and Sipplingen, Germany, are riding (see below) to avoid stooping or crawling through their assignments. Reminding us of a wheeled bobsled, the vehicle makes the inspection job fast and, not loose, but easy. And during droughts, of course, it can provide wonderful subway transportation.



(Continued on page 64 P&R)



AT TEN PLANTS ACROSS COUNTRY, the Jones Company receives tank cars of Chlorine, repackages it in cylinders and ton-tanks, makes quick deliveries to users in area.

CHLORINE

Fast delivery on less-than-carload lots

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LIQUID CHLORINE
In 16-, 105-, 150-lb. cylinders and 1-ton tanks.



CALCIUM HYPOCHLORITE
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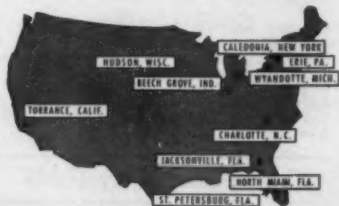


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Gallons, carboys. Tankwagon deliveries in 1000-3000 gal. lots.

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Wyandotte, Mich.

(Continued from page 62 P&R)

Tanks, no thanks! must be the prevailing opinion in the Village of Ridgewood, N.J., these days, now that the village is faced with disassembling and removing a 160-ft high, \$80,000 elevated tank that has been 75 per cent completed since April 1956. The disassembly, as one might suppose, will not be exactly voluntary, but by order of the New Jersey Supreme Court acting on the complaint of the neighboring town of Ho-Ho-Kus over one of whose finest residential areas the tank would tower. Actually, it was not the towering, but the fact that it stood partly on Ho-Ho-Kus land that led to the court's upholding an order for its removal. Meanwhile, Ridgewood officials, who had received an informal Ho-Ho-Kus okay, apparently on the understanding that the tank was to be a ground level one, screened by trees, were looking for another way out.

Another way out, meanwhile, may have been turned up by Douglass Welch, New York *Journal-American* columnist, who, quite unconscious of Ridgewood's predicament, was con-

ducting a discussion with one of his readers concerning experiences with elevated tanks that prowled at night. Agreeing fully with Frank Amsbary, whose letter to Welch called attention to the fact that, though tanks may walk at night, they would do so for strictly beneficial purposes and could certainly not be said to prowl, we wonder if Ridgewood might consider completing its tank and seeing if it will take the necessary steps with the help of a Ho-Ho-Kus-pokus or two—or, failing that, letting it ride, as did another tank not long ago (see July P&R, p. 38).

Still another way, of course, would be camouflage, such as is even now being used at Velbert, Germany, where a modern apartment house is being constructed to surround, enclose, and, thus, completely secrete an elevated tank. Or would an apartment house in such an exclusive area have to say: Thanks, no tanks!



Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: \$1.50 per line (minimum \$5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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Position available for a well educated, aggressive young Engineer with several years' experience as an Engineer and Chemist in the field of water supply. Unusual opportunity for advancement and professional recognition on Long Island with an expanding organization comprised of a large group of properties. Salary commensurate with experience and ability. Interview arranged on basis of letter stating qualifications, educational background and salary desired. Reply Box 881A, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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QUICKLY **SIMPLY**

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MUELLER® Tapping Sleeves and Valves are your most practical—and economical—means of connecting lateral or branch mains.

Connections are quickly made under pressure with the new Mueller CL-12 Drilling Machine—*there is no shutdown, no loss of water, no interruption of flow in the main!*

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The Reading Meter

Multiple Purpose River Development. John V. Krutilla & Otto Eckstein. Johns Hopkins Press, Homewood, Baltimore 18, Md. (1958) 301 pp.; \$4.50

This work analyzes multipurpose river development from the standpoint of economic efficiency. The authors begin with a review of conditions that would have to prevail for the free play of market forces to bring about the maximum economic output consistent with the preferences of consumers. They then note some special aspects of river development that would not be taken into account adequately, if at all, by operations of the free market—for example, the fact that pollution abatement and flood control are collective goods rather than salable products. The authors conclude that “public participation in the water field is required if efficiency is to be achieved.”

The authors inquire into the true social cost of tax-financed federal investment funds and conclude that this would represent an interest rate of between 5 and 6 per cent—a substantially higher figure than the rate actually paid on federal bor-

rowings. They arrive at this range by tracing the probable effects on the national economy of decreases in federal taxation that could take place if a given project were not undertaken by the federal government. They estimate, that is, what the alternative investment possibilities would be.

Applying this analysis to the Hells Canyon case, they suggest that neither the three-dam development now licensed by the Federal Power Commission nor the single high-dam proposal that was supported by many advocates of public power would represent the most economically efficient plan for that reach of the Snake River. They find instead that a two-dam system—not seriously considered during the long controversy—rates higher in terms of economic costs and benefits. Other examples are also analyzed, and consideration is given to the effects of different types of development upon income distribution—that is, the probable patterns of gains and costs among the people in the area immediately involved, as well as in other regions.

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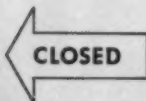
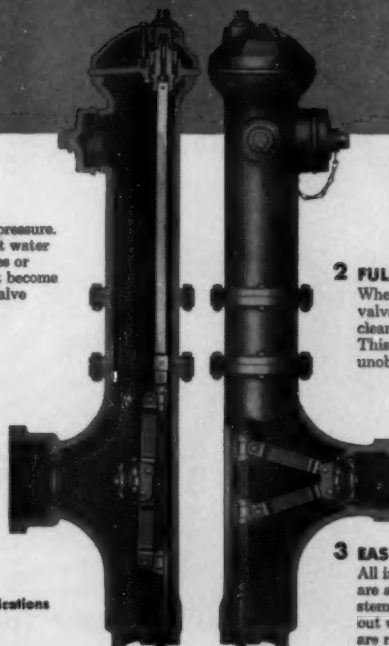
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Opens fast, with the pressure.
Closes slowly, without water
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lodged between the valve
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When hydrant is fully opened,
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This permits free and
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All internal working parts
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stem, which is easily lifted
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are removed. Common wrench
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are needed.

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The raw water's loaded with problems, but

Dubuque gets 10



100-hour filter runs with Permutit Precipitators

Influent at Dubuque's new Eagle Point water treatment plant is loaded with iron, manganese and a hardness of 320 ppm. When you're working with raw water like that, the chances for long filter runs would ordinarily be slim.

Yet two vertical Permutit *Precipitators* hold their blankets effectively even while handling the precipitates from this highly mineralized raw water. The effluent they produce is so low in floc-carryover that very little load is placed on the filters. Result: Getting 100-hour filter runs is no problem at all. Precipitation is complete; there's no troublesome lime build-up on the filter sand.

The high efficiency of the *Precipitator's* unique upflow sludge blanket has shown up fast in low operating costs for the Eagle Point plant. Long filter runs mean less treated filter-wash water is used, hence pumping and chemical costs are both reduced.

Permutit can help you come up with the right answer to your community's water problems. Just contact the Permutit office listed in your phone book. Or write to us directly. The Permutit Company, Dept. JA-9, 50 West 44th Street, New York 36, New York; or Permutit Company of Canada Ltd., Toronto 1, Canada.

Two Permutit *Precipitators* treating 12 million gpd at the Eagle Point Water Plant, Dubuque, Iowa. Plant designed by Consoer Townsend & Associates, Chicago, Ill.

PERMUTIT®

rhymes with "compute it"

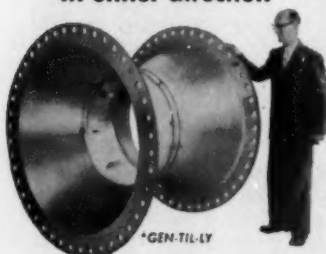
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FLOW TUBE
 measures flow
 in either direction



REVERSIBLE . . . The Flow Tube is symmetrical, with upstream and downstream ports identical. When the flow is reversed, the differential is reversed. Permits metering reverse flow at lowest possible equipment cost.

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LOWEST HEAD LOSS . . . The Flow Tube can be designed to produce a measurable differential with the lowest permanent pressure loss of any type head meter.

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*Service
 Lines*

A valve position transmitter, which translates the position of remote mechanisms into terms of output pressure, is the subject of a 2-page leaflet. Illustrated with photographs and line drawings, the bulletin (No. 285-R1) is available from Builders Providence, Inc., 345 Harris Ave., Providence 1, R.I.

Dissolved air flotation, for removing suspended matter from water, is discussed with photographs and diagrams in a 12-page bulletin. This publication may be obtained from Dept. P.R., Chain Belt Co., Milwaukee 1, Wis.

Nine different valves and their uses are the subject of an illustrated 8-page bulletin (No. G-5A). Copies are available from Golden-Anderson Valve Specialty Co., 1221 Ridge Ave., Pittsburgh 33, Pa.

Junior spectrophotometers, available in three models and with a choice of four power supply arrangements, are described in a 6-page folder. Cuvettes and cuvette adapters are also discussed in the bulletin, No. B-240-A, which may be obtained by writing to Coleman Instruments, Inc., 318 W. Madison St., Maywood, Ill.

A V-notch positioner, for automatic control of chlorinators, has recently been developed and is described in a 4-page technical bulletin. Copies of the publication may be obtained from the manufacturer, Wallace & Tiernan Inc., 25 Main St., Belleville, N.J.

(Continued on page 72 P&R)

MORE WATER FOR SPRINGFIELD

Armco Pipe with made-to-order fittings cuts installation time at new Springfield, Ohio, water works

Springfield, Ohio, is joining hundreds of other cities using Armco Welded Steel Pipe to meet the increasing demand for water. At the new Springfield water works, Armco Pipe in 24- to 36-inch diameters was installed for influent, filter, wash, waste, and discharge lines.

Armco fabricated standard and special fittings to the plan, and supplied them attached to straight lengths of pipe. This saved the time and expense of field joint or a pair of flanges at each fitting.

Armco Pipe can help solve *your* water supply problems too. Write us about your particular requirements, or for prices and delivery data. Armco Drainage & Metal Products, Inc., 4498 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

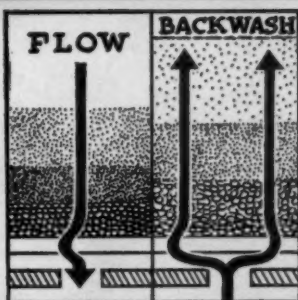


Armco Welded Steel Pipe



feco FRE-FLO FILTER BOTTOMS

Cut Your Filtration Costs



UNIFORM FLOW AND BACKWASH

Practical design assures constant flow and uniform backwash. With a backwash rate of 30" rise (50% sand expansion) the total loss of head is only 2.5 ft. of water resulting in initial savings by purchasing a lower h.p. motor for the pump . . . and continuous savings in pumping costs.

Non-corrosive filter bottoms are scientifically manufactured so that the ports cannot be blocked by gravel . . . closed by encrustation . . . or enlarged. Strong, durable construction withstands many times the force of the severest filter run. About five minutes and a screw-driver completes field assembly and substantially reduces labor and costs.

Write For Literature

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ROCHESTER 21, N. Y.

Service Lines

(Continued from page 70 P&R)

Rubber-seated butterfly valves, said to be designed to conform with AWWA Standard C504, are discussed in an 8-page booklet, No. 581. Photographs, tables, and detailed drawings are included in the bulletin, which is available from W. S. Rockwell Co., 200 Eliot St., Fairfield, Conn.

Tapping of concrete pressure pipe is the subject of a 12-page, illustrated, pocket-size booklet. The step-by-step procedure for making large and small taps and service connections to prestressed concrete pipe is completely described. Copies may be obtained from Price Brothers Co., 1932 E. Monument Ave., Dayton 1, Ohio.

Sealed-register meters are described in a new, multicolor 20-page catalog. Features of the new meter include a hermetically sealed register and a magnetic drive. Complete with photos and diagrams, the bulletin (No. W-811) may be obtained by writing to Municipal & Utilities Div., Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.

Steel pipe is the subject of an illustrated 4-page folder which gives suggestions for gaining the most in strength, security, and savings from this material. Copies are available by requesting P. O. 7958 from Product Information Service, Armco Drainage & Metal Products, Inc., Middletown, Ohio.

The continuous-titration method of slurry control, using controlled-volume pumps, is the subject of a 4-page leaflet which discusses the process in detail and includes a schematic diagram. Data Sheet A-58-2 is available on request from Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.

put the
blame
on
mains,
boys



Did you hear a lot of customer complaints about low water pressure last summer? After the spring's heavy rains which filled reservoirs to the brim all over the country, *there should be no water shortage.* The problem probably rests underground . . . mains and distribution grids choked by pressure-killing tuberculation and corrosion.

There's one sure cure for your pressure problem . . . the Centrline Process. Centrlining permanently increases carrying capacities in all sizes of pipe by eliminating tuberculation and corrosion forever. After loose scale and tubercles are re-

moved from the pipe, the Centrline machine applies a smooth, uniform coating of cement-mortar to the pipe wall by centrifugal force. Fast and economical, Centrlining is accomplished with a minimum of interruption to surface traffic, since the pipes are lined in place and excavations are not required at laterals and services.

With the introduction this year of the new, small diameter Centrline machine, you can permanently protect all water lines from 4 to 144 inches in diameter. Send today for our new brochure which fully describes the Centrline Process.

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Branch Offices in Principal
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Section Meetings

Pennsylvania Section: The Pennsylvania Section held its tenth annual meeting at the Lawrence Hotel, Erie, Jun. 24-26. The official registration was 251, including 62 ladies who enjoyed the festivities.

A get-together was held on the evening of Jun. 24 through the courtesy of WSWMA. The official program, which began on the morning of Jun. 25, consisted of three technical sessions. These were unusually well attended and a number of very excellent presentations were made by very able speakers. [A list of papers presented will appear in the December 1958 JOURNAL.]

On the afternoon of Jun. 24, there was a tour of the Erie water and sewage treatment plants, and during that period a golf tournament was also held. On Wednesday evening a fish fry was held at Presque Isle State Park, which stretches out into Lake Erie, and the participants enjoyed a trip by bus and boat to Presque Isle,

but were deluged by a sudden squall on their return to the dock.

At the noon luncheon on Jun. 26, Life Membership Certificates were presented to Elwood L. Bean, G. M. Ornsen, and Willard F. Rockwell. At the annual banquet held that evening the main address was delivered by President Finch. The Fuller Award nominee of the Section was Reginald B. Adams, superintendent of purification, Wilkesburg-Penn Joint Water Authority. One of the features of the program was a presentation of the Safety Awards for the first time in the Pennsylvania Section. Twenty were given out—one Award of Honor, two Awards of Progress, and seventeen Awards of Merit—to various water works which had met the safety program requirements. A social hour was hosted by WSWMA prior to the banquet and afterward, during the dance.

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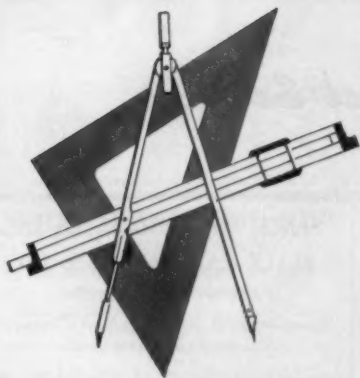
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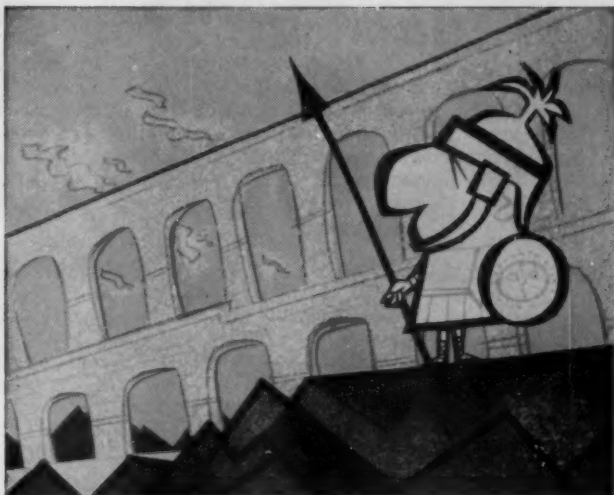
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CHEMICAL ANALYSIS

Determination of Small Amounts of Acrylonitrile in Aqueous Industrial Streams. G. W. DAUES & W. F. HAMNER. *Anal. Chem.*, 29:1035 ('57). Method which is useful in waste-disposal studies has been developed for the detn. of low concns. of acrylonitrile in water. Method is based on concn. of acrylonitrile and its sepn. from other components by an azeotropic distn. with methanol coupled with polarographic anal. Method can be applied to wide variety of water samples, regardless of other components present, and as little as 0.1 ppm acrylonitrile has been detected.—*WPA*

Colorimetric Determination of Aluminum in Industrial Water Containing Iron. K. Goro. *Chem. & Ind. (London)*, 329 ('57). In all of colorimetric detns. of Al in industrial water, iron is interfering substance. Author shows that *o*-phenanthroline (I) can be used as masking agent for Fe. Procedure consists of using 30-ml portion of soln. contg. less than 4 ppm of Al. To this is added 0.5 ml of 1:10 HCl and 1 ml of 10% hydroxylamine-HCl. This is gently heated and cooled. Then 3 ml of 0.12% I and 0.5 ml of 40% Na acetate are added followed by 3 ml of 1% 8-hydroxyquinolinol and 2 ml of Na acetate. This mixt. is shaken for more than 1 min in a sepg. funnel with 10 ml CHCl_3 . CHCl_3 extract is washed with distd. water and dried over anhyd. sodium sulfate. Absorption is measured at 400–420 μ .—*CA*

Geochemical Studies of Boron. XII. Seasonal Change of Chemical Composition of River Water. S. MUTO & Y. KITAZUME. *Nippon Kagaku Zasshi*, 78:34 ('57). Waters of Kiriu R. were taken every mo. for

1 yr (Apr. '55–Mar. '56) and analyzed for Cl, Na, K, Fe_2O_3 + Al_2O_3 , Ca, Mg, sulfate, Si, and B. In Jun. B showed a max. concn. (15 mg B/l), when the river dischg. was lowest. High B concn. (about 10 mg/l) in Nov. and Dec. is thought to be caused by leaching from the remains of plants. Ratio of B to Cl was compared with that of N. Am. rivers.—*CA*

On Mohr's Method for the Determination of Chlorides. R. BELCHER; A. M. G. MACDONALD; & E. PARRY. *Anal. Chim. Acta*, 16:524 ('57). In view of conflicting statements which have been published on MOHR's method for detn. of chlorides, authors investigated factors affecting accuracy of this method. Methods for detg. blank value were compared, and use of suspension of calcium carbonate was found to be most convenient. Better control of final pH value of soln. is obtained if indicator is neutralized. Effect of phosphate and arsenate was found to be less serious than is generally supposed, and fluoride had no effect at all. Oxalate interferes at all concns., but this can be overcome by pptn. as calcium oxalate. Iron also interferes but can be partially masked with fluoride. Contrary to general opinion, aluminium causes only slightly high results, and zinc has no effect at all. Attempts to use EDTA to mask cations which normally interfere were not successful.—*WPA*

Recommended Methods for the Analysis of Trade Effluents. Methods for the Determination of Chromium, Lead, and Selenium. A.B.C.M.—S.A.C. Committee on Methods of Analysis. *ANON. Analyst*, 81:607 ('56). Specific procedures for colorimetric detn. of Cr with diphenylcarbazide and Pb with dithizone, and nephelometric detn. of Se in industrial wastes are described.—*CA*

(Continued on page 86 P&R)

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(Continued from page 84 P&R)

Titrimetric Determination of Fluorine in Natural Waters. S. K. CHIRKOV. Zhur. Anal. Khim. (Moscow), 12:762 ('57). F⁻ was successfully titrated with Th(NO₃)₄ at pH 2.0-2.3 in presence of Alizarin S as indicator (cf. DUBNIKOV & TIKHOMIROV, *CA*, 42:8706g). Effect of SO₄²⁻ was neutralized with CaCl₂ or MgCl₂. At any rate the concn. of SO₄²⁻ may not exceed 100-120 mg/l. pH of soln. was adjusted with 0.1N HCl. —CA

Distribution of Germanium and Lithium in Jumanjigoku Springs of the Spa Beppu. H. MINATO. Okayama Daigaku Onsen Kenkyusho Hokoku (Jap.), 18:22 ('57). Ge and Li were detd. spectrometrically in water samples from 4 springs of Jumanjigoku. Ge was distributed equally in all samples. Li content of the water from drilled well was higher than that of naturally issuing waters. —CA

Hydrogeology and Geochemistry of the Iodine-Bearing Medicinal Springs in Ciz and Its Neighborhood. J. JANACEK. Geol. prace (Czech.), 47:117 ('57). Chem. anal. of 5 waters, including detns. of Br, I, and B, show them to be high in NaCl content and to contain CH₄. They are considered to be fossil oil-field brines, partly metamorphosed with the addn. of CO₂. —CA

Use of Iodine Chloride in Analytical Chemistry. V. Determination of Cyanides and Thiocyanates. J. CIHALIK & K. TEREBOVA. Chem. listy (Prague), 50:1761 ('56). Method is described for the detn. of thiocyanates and cyanides using iodine chloride. Sodium bicarbonate soln., contg. cyanides, is titrated against iodine chloride, end-point being detd. either potentiometrically or using starch as indicator. Chloride or bromide ions in excess do not interfere with reaction but iodides must not be present in greater than tenfold excess. Thiocyanate is titrated

(Continued on page 88 P&R)



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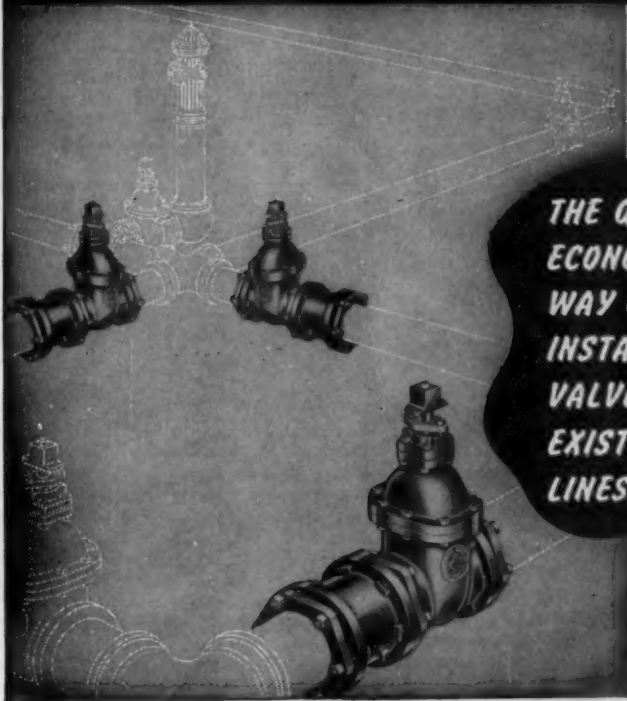
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(Continued from page 86 P&R)

in slightly acid soln. (0.5% hydrochloric acid) or in sodium bicarbonate soln. with avg. error of ± 0.5 or 0.34% respectively. To det. mixt. of cyanides and thiocyanates, cyanides plus thiocyanates are first detd. by titrating in sodium bicarbonate soln. Cyanide is then removed by adding acid and heating; excess of bicarbonate is added and thiocyanates detd. by titrating against iodine chloride.—WPA

Ion Composition of the Water of the Reservoirs of the Northeastern Near-Azov Region. M. N. TARASOV. *Gidrokhim. Materialy* (Moscow), 25:154 ('55). It is shown how compn. of H_2O in reservoirs with respect to salts contained therein can be explained on basis of the anal. of surface waters which run off soils into such reservoirs. All ions increase in their concn., with exception of Ca^{++} and HCO_3^- , which are lost from H_2O by reactions like $Ca(HCO_3)_2 \rightleftharpoons CaCO_3 + H_2O + CO_2$.—CA

o-Phenanthroline Method Applied to the Determination of Iron in Natural Waters. S. TANAKA. *Okayama Daigaku Onsen Kenkyusho Hokoku* (Jap.), 7:1 ('56). o-Phenanthroline was used to det. Fe^{++} and Fe^{+++} in natural waters separately with sufficient accuracy. Ionic Fe and colloiddally dispersed Fe were also separately detd. by this method when the dispersed Fe was present in amts. more than 1.3% of total Fe.—CA

Evaluation of Iron-Sequestering Agents in Water Flooding. W. E. BELL & J. K. SHAW. *Producers Monthly*, 22:5:20 ('58). Lab. procedure with Millipore Filters for evaluating sequestering agents has been devised and details are presented. Exptl. data were obtained by measuring the flow of aerated water contg. 4 ppm Fe^{+++} past a Millipore Filter disk. Tetraphosphate, pyrophosphate, ethylenediaminetetraacetate, and citric acid were effective in sequestering Fe^{+++} in distd. water. Same test was also carried out by using water with Na 22,000, Cl 36,400, Ca 1,200, Mg 200, SO_4 300, and HCO_3 350 ppm. In this water, citric acid was found to sequester Fe^{+++} much more effectively than tartaric acid, tetraphosphate, gluconic acid, glucoheptonic acid, N,N-bis(2-hydroxyethyl)glycinate, pyrophosphate, tri-

polyphosphate, ethylenediaminetetraacetate, and lactic acid. Citric acid was only sequestering agent found to prevent pptn. of insol. Fe compds. in presence of Ca, Mg, and O.—CA

The Determination of Phenols in Water. W. HERMANOWICZ & H. CZARNODOLOWA. *Gaz. Woda i Tech. Sanit. (Warsaw)*, 32:60 ('58). Investigations concerned methods of stabilizing aq. solns. of phenols, their distn. with steam, and detn. by reaction with (1) W molybdate, (2) diazotized p-nitroaniline, (3) diazotized sulfanil acid, and (4) 4-aminoantipyrine. Method 1 seems to be most useful for mixts. of phenols. Others give similar reactions with "nonphenolic" compds., so therefore can be used only for detns. in aq. solns. contg. only 1 phenol. Combination of methods 1 and 4 is suggested.—CA

Chemical Studies on the Hot Springs of Beppu. V. Radioactive Elements. A. KOGA; H. NOZAKI; & H. KAWAKAMI. *Nippon Kagaku Zasshi* (Tokyo), 8:642 ('57). Contents of Rn and Ra of 50 springs of Beppu were detd. Max. Rn value is 5.21×10^{-10} curie/l of Jizo Spring, Myoban Dist. Highest Ra concn. is 6.47×10^{-10} g/l of Chinoike Spring. Avgs. for 50 springs are 0.83×10^{-10} curie Rn/l and 1.13×10^{-10} g Ra/l, resp. Rn that is in equil. with Ra is less than 5% of total Rn. High-Rn values tend to be found in acid springs and bicarbonate springs. Ra in spring sediments is enriched in colored parts, max. being 10.67×10^{-10} g Ra/g.—CA

The Formation Conditions of Sodium Chloride-Containing Waters of the Krivbass [Krivorozhsk Iron Ore Deposits]. V. D. NOTAROV. *Geol. Zhur., Akad. Nauk. Ukrain. R.S.S.R., Inst. Geol. Nauk. (USSR)*, 16:3:38 ('56). Anals. are presented of waters under discussion at several depths for K + Na, Ca, Mg, Fe, Br, Cl, SO_4^{--} , and HCO_3^- and compared to those of seawater and water of several mines. Several theories had been proposed for formations of such waters; based upon expts. it is concluded that main reason for distr. of mineral compn. in various layers as found at these subterraneous waters is magnitude of gravitational pull, which will act differently on various ions, thus bring about zones.—CA

(Continued on page 90 P&R)

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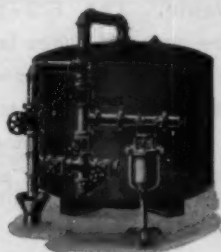
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(Continued from page 88 P&R)

Potentiometric Determination of Sulfates, Chlorides, and Nitrates in Water. A. WAGNER. Bull. Centre Belge Etude et Document. Eaux (Liege), 3:164 ('57). Rapid detn. of SO_4^{--} , NO_3^- , and Cl^- is suggested. By potentiometric method simultaneous detn. of these ions is made possible; alkalimetric titration with $\text{Ba}(\text{OH})_2$ after passing soln. through ion-exchange column detn. the sum of SO_4^{--} , NO_3^- , and Cl^- . Soln. is then titrated with K palmitate soln., giving sum of NO_3^- and Cl^- and with AgNO_3 to det. the Cl^- content. In all cases carbonates have to be removed by means of CO_2 -free air. Phosphates also interfere and must be pptd. by addn. of basic Pb carbonate. Results are in exact agreement with those obtained with other methods.—CA

Determination of Spent Sulfite Liquor in Waters. I. HEDLUND & K. WILSON. Svensk Pappersliden. (Stockholm), 60:582 ('57). Ratio (I) between absorbancies at 265 and 280 μ was found to be very much same, about 1.21, in waters free of spent sulfite liquor (II). For II in natural water I was 0.76 and changed rather slowly. Formula is given for calcn. of amt. of II from detn. of 2 absorbencies.—CA

The Nature of the Coloring of the Waters of Dnieper. L. A. KUL'SKII; M. A. SHEVCHENKO; & F. S. CHUBUK. Gidrokhim. Materialy (Moscow), 25:59 ('55). Color of waters of Dnieper is due to org. compds. which fluctuate from 20 to 80 mg/l during yr. Main mass consists of dissolved and colloidal humic compds. in various stages of transformation, 90% being fulvic acids and rest humic acids. Some of fulvic acids are pptd. by Al_2O_3 , and others are not affected. Those which are pptd. are responsible for color of water, others are not contributing factor, but they interfere with discoloration due to their protective action upon Al_2O_3 . Activated charcoal is of little effect. Best results are obtained by making use of adsorbing and strong oxidizing agents.—CA

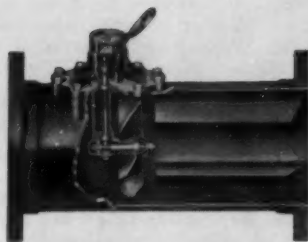
The Hydrochemistry of the Underground Waters of the Northwestern Balkhash Territory. E. V. POSOKHOV. Gidrokhim. Materialy (Moscow), 25:183 ('55). Salinity of this territory is of variable nature, approaching in some places that of ocean. However, most characteristic feature is high

(Continued on page 92 P&R)

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(Continued from page 90 P&R)

content of sulfates which are derived from sulfides present in ores. Oxidation of sulfides produces H_2SO_4 which attacks and dissolves some of metals present in ores: Fe, Cu, Pb, and Zn. Main cations are Ca and Al. With time, increase of Ca sulfates leads to their sedimentation and replacement by Cl ions.—CA

Spectrophotometric Characteristics of Col-orimetric Reactions. A. V. FEDOREVA. *Gidrokhim. Materialy* (Moscow), 25:217 ('55). Use of spectrophotometer and photo-colorimeter in anal. of drinking waters is recommended. However, it has been found to be inapplicable in some reactions: I-starch, diphenylamine (nitrates), phosphomolybdic acid (phosphates), and sulfosalicylic acid (Fe).—CA

The Chemical Composition of the Sub-terraneous Waters of the Bychakskii-Kanevskii Water-Bearing Layer of the Dnieper-Donets Depression. I. I. TSA-PENKO & M. P. ELISEEVA. *Geol. Zhur., Akad. Nauk. Ukrain. R.S.R., Inst. Geol. Nauk. (USSR)*, 16:3:44 ('56). Majority of these waters contain from 0.5 to 3 g/l of salts, which are predominantly NaCl and $NaHCO_3$. If water becomes stagnant, mineral content increases to 12 g/l and is predominantly NaCl. There are all kinds of transitions in H_2O anal., depending upon contact of H_2O with glauconite, phosphorite, bitumina, and other soil components, and enrichment of NaCl and decrease in $NaHCO_3$ content are accompanied by changes of other characteristic coeffs., thus, e.g., $HCO_3/(Ca + Mg)$ changes from 2 to 8 and even 10, whereas Na/Cl coeff. changes from 8-10 down to 1. Similar regularity is found for Cl/Br coeff.—CA

CORROSION

Detecting Corrosion in Water Mains. T. SAMUEL. *Bul. Centre Belge Etude Document. Eaux* (Brussels), 62:63 ('56). In expts. to investigate rate of corrosion of water mains, 6 soft-steel tubes were placed in 2 sections of water main, 1 of which carried raw water and other treated water. Compn. of each water is given in table. Tube was removed from each section at bimonthly intervals, examd. macroscopically,

deposits analyzed, depth of corrosion detd., and oxide deposit examd. by X-rays. Tables of results and photographs are given. Results indicate that presence of large friable tubercles and concn. of less than 3% calcium in deposit can both be used to detect corrosion in its early stages.—WPA

Nonchemical Factors Affecting Inhibitor Selection and Performance in Air-Conditioning Cooling Waters. S. SUSSMAN. *Corrosion*, 13:701t ('57). Rapid increase in use of air-conditioning equipmt. has resulted in increased cooling-water corrosion problems. Author discusses economic, mechanical, and legal factors which affect control of corrosion in such systems by means of chem. inhibitors. Factors which may affect eff. of inhibitor are use of untrained personnel and inconvenient location of equipmt. In many cases, selection of inhibitor and its use are restricted by legal requirements pertaining to cross-connections, water conservation, or waste disposal.—WPA

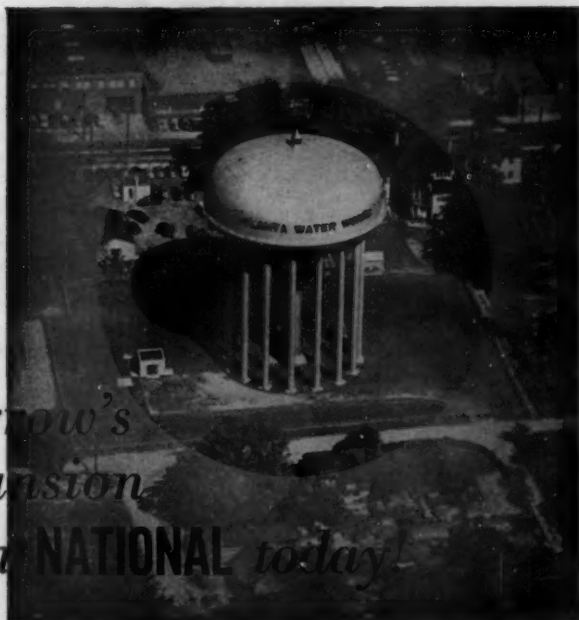
Aggressivity of Drinking Waters and Soils. R. HOFFMANN. *Bul. Centre Belge Etude Document. Eaux* (Brussels), 34:266 ('56). Corrosion of iron by water and soil is described and methods of protecting iron pipes from corrosion are discussed briefly. Anals. of corrosive waters of several communities in Luxembourg are given. Corrosive nature of some soils was studied by burying in soil tubes of steel protected by zinc anodes, normal steel and iron, and eternite. Tubes were examd. for corrosion after 34 mo.—WPA

Inhibiting a Cooling Water Tower System. F. L. WHITNEY. *Corrosion*, 13:711t ('57). Author discusses, with reference to experiences at specific plant, effect of atmospheric contamination on eff. of inhibitor used to control corrosion in recirculating cooling-tower systems. Importance of lab. and field tests to insure proper protection, is stressed.—WPA

Research on Aggressiveness of Water and the Composition of Products of Incrustation or of Corrosion. T. SAMUEL. *Bul. Centre Belge Etude Document. Eaux* (Brussels), 35:49 ('57). Author discusses general and local corrosion of metals. Ag-

(Continued on page 94 P&R)

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(Continued from page 92 P&R)

gressive nature of water is indicated by satn. index. If this is positive, calcium carbonate scale may be deposited, but if it is negative, corrosion may occur. It is advisable to carry out macroscopic and oblique-section examns. of sample tubes placed in water before deciding upon treatment.—WPA

Some Experiences With Sodium Silicate as a Corrosion Inhibitor in Industrial Cooling Waters. J. W. WOOD; J. S. BEECHER; & P. S. LAURENCE. *Corrosion*, 13:719t ('57). Authors discuss use of sodium silicate for control of corrosion in open, recirculating, cooling-water systems and consider normal development of silica films and effects of previous corrosion, pH value, water temp., and magnesium hardness. Data obtained in long-term tests indicate that crystalloidal silica is very effective in stopping corrosion of mild steel by wide variety of industrial cooling waters. Addn. of 30-40 ppm total crystalloidal silica gave adequate protection in waters containing more than 500 ppm chlorides and sulfates. Magnesium

hardness in concns. greater than 250 ppm (as calcium carbonate) was found to reduce inhibitive action of silica.—WPA

Treatment of Corrosive and Scale-Forming Water. E. WOLDICKE. *Sanit. Tech. (Berlin)*, 20:404 ('55). After describing harmful effects of corrosive and scale-forming waters on distr. systems and hot-water pipes, author describes methods of treatment. Treatment with hexametaphosphate is used to keep hardness-forming substances in soln. By magnetochem. processes dissolved salts are affected by magnetic field so that normal crystallization does not take place. Effect of ultrasonic waves is similar. These methods do not prevent corrosion for which best method is GULDAGER's electrochem. process. In this, whole supply system serves as cathode and aluminium rod is inserted as anode. Voltage and power requirements are low. D-c is obtained from supply system through transformers and rectifiers. Strong alkali is formed near pipe walls and hardness-forming compds. are deposited as sludge.—WPA

(Continued on page 96 P&R)

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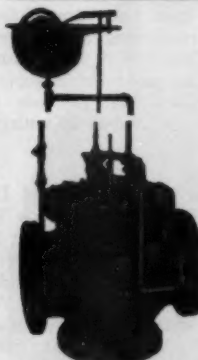
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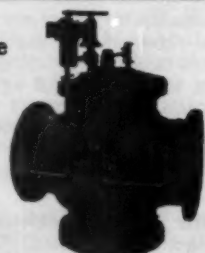
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(Continued from page 94 P&R)

Several Methods of Rendering Corrosive Drinking Waters Harmless. A Description of Experimental Methods. T. SAMUEL. Tech. Eau (Brussels), 10:109:48 ('56). Author considers control of pitting type of corrosion found in water distr. systems. This type of corrosion is said to be caused by metallic oxides polarizing metal and increasing its tendency to corrode. It has been suggested that chloride and manganese ions present in some waters may increase rate of corrosion, since they act as intermediaries in oxidation of metals. At Centre Belge Etude et Document. Eaux, methods of examg. systems for corrosion are being developed. Corrosion of 0.01 mm in depth can now be detected.—WPA

FOREIGN WATER SUPPLIES

Water: Essential to Life. Good Health, Adelaide (Australia), 104:21 ('57). Importance of water to life is summarized and sources of water are classified. Water supplies in state of S. Australia constitute constant health and economic problem because rainfall is low and, therefore, must be collected and conserved in places of good supply and piped to places that need it. Water, drawn from R. Murray at Morgan, is piped to Whyalla and scheme, capable of supplying 53 mgd, for bringing Murray water by pipe from Mannum to Adelaide has been developed. Water supply for Adelaide and its suburbs is obtained from watersheds of Torrens and Onkaparinga rivers and from the R. Murray and is stored in 5 reservoirs, total capac. 14,000 mil gal, that supply metropolitan area. Std. tests for water supplies and supplies for swimming pools are given. Hazards present in water supplies and methods of treatment to remove them are outlined. Map is included showing distr. of water in S. Australia.—WPA

Water Supply Problems in the Belgian Congo. G. BORGNEZ. Tech. l'eau (Brussels), 9:105:19 ('55). Difficulties encountered in obtaining adequate potable water supplies for large and small communities, commercial, industrial and educational centers, hospitals, and for cattle and other domestic animals in Belg. Congo, are outlined. Irrig. and drainage problems, and those of irregularity of flow in water courses, are

mentioned briefly. Illustrated description is given of methods whereby potable water supplies have been made available to all types of communities, and of location of many new sources of supply in different Congo prov. Supplies were previously obtained from wells and springs, which easily became contamd., and these have been improved by the installation of small metal reservoirs or concrete basins, and by addn. of 1 of 2 types of pump to existing wells. Many water mains and pipes have also been laid to insure that supplies reach outlying areas and particularly arid zones, and to make use of small streams which would otherwise run to waste. Water is aggressive, and is treated to raise pH value by the addn. of local limestone which has been ground. Resistance of concrete to action of water is increased either by incorporation of suitable substances, or by painting or whitewashing. Owing to corrosive qual. of water, steel is often replaced by copper or plastic pipes, or protective linings are used. Expts. are described which resulted in these improvements and extensions, and details of constr. of equip. and its maint. are given.—WPA

Water Supplies in Belgium. M. A. ACHTEN. Bull. centre belge etude et document. eaux (Belg.), 30:254 ('55). Author reviews water supplies and resources in Belg. and considers country's future needs. At present, nearly all supplies are obtained from ground water and it is considered that these resources can meet estd. demand from new and existing consumers for the next 15-20 yr. Surface water from Meuse basin can then be used for augmenting supplies and it is recommended that methods for obtaining this water be studied in anticipation of need.—WPA

Ashton-under-Lyne, Stalybridge and Dukinfield (District) Water Works. A Review. J. Br. Waterworks Assn. (Br.), 39:286 ('57). Historical acct. is given of development of water supply for Ashton-under-Lyne, Stalybridge, and Dukinfield dist. Water is obtained from moors of Swineshaw and Greenfield. It is of good bact. qual., but is very acid, and is treated at Ashway Gap and Brushes filter plants. Capacs. of these plants were increased in '50 and '51 by installation

(Continued on page 98 P&R)



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of addnl. pressure filters. To control algal growths in Knott Hill service res., filtered water is treated with ozone. To meet increasing demand, 3 boreholes have been constructed in the Swineshaw Valley, giving an addnl. yield of 500,000 gpd. Investigations are in progress on possibility of developing catchment area and res. site within 6 mi of Ashton; use of this source would double existing safe yield of water undertaking. Data are given in tables showing pop. in dists. served and information on catchment areas, reservoirs, and storage capacity. Map of catchment area and area of supply is included.—WPA

Water Supplies in French Oceanic Settlements. A. BERNAST. *L'Eau* (Paris), 43: 101 ('56). Oceanic settlements (pop. approx. 22,000) receive their water supplies from numerous distinct water supply networks developed throughout territory. All water supplies are free. In higher altitude islands, such as Tahiti, Moorea, and Marquesas islands, water supply is taken from mountain torrents using hydraulic equip., but this is not possible in lower coral-reef formations. Water is treated by prelim. sedimentation and stored in reservoirs followed by final sedimentation and storage in covered reservoirs. Algal growths are scraped off walls when sedimentation tanks are desludged, but in a few cases fish fry invade sedimentation tanks and consume algal growths. Author describes distr. systems and outlines work which has been done in relation to fluoridation and dental caries.—WPA

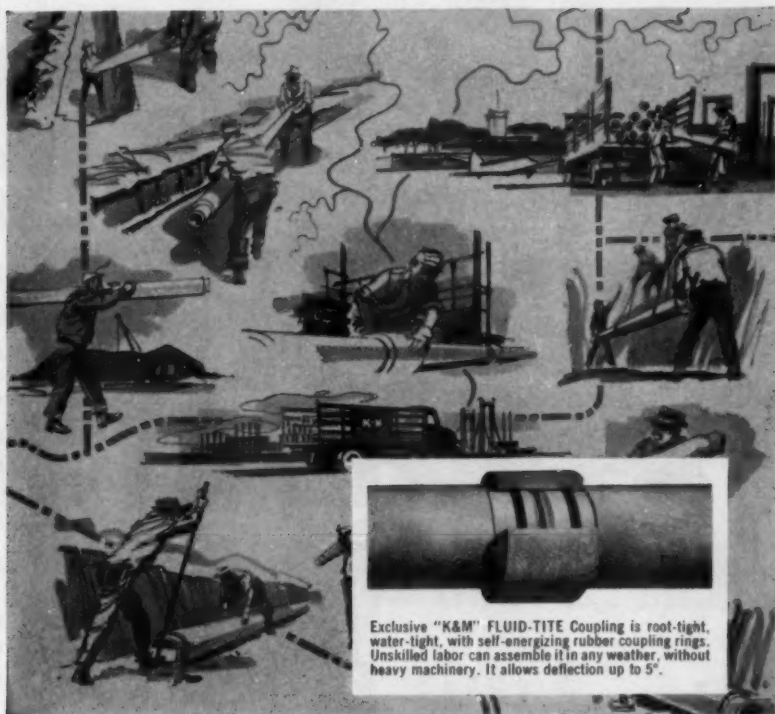
Meeting the Water Demand by Bank-Filtered Water. D. LANG. *Bull. centre belge etude et document. eaux* (Belg.), 31: 41 ('56). Need for source of extra water supply for towns of Düsseldorf and Wuppertal is outlined. It is planned to use bank-filtered water from R. Rhine, which permeates through ground and adds to total supply of ground water. Eq. is given which enables value for the permeability of the soil to be calcd. Geological and hydrological data are given in tables of area "Auf dem Grind," which is considered most suitable one from which extra water supply may be obtained. Diagrams of area are included. Qual. of ground water is good, but treatment will be necessary to remove

tastes and odors. Thorough chem. and bact. anal. are to be made after treatment, to insure potability. Treatment plant, pumping station and 2 wells with horizontal infiltration galleries are to be installed; details of constr. of wells and pumping station are given in diagram.—WPA

Karlsruhe—Water Supply. K. KONINGER. *Gas- u. Wasserfach.* (Ger.), 98:546 ('57). In recent yr Karlsruhe has developed into industrial town with great increase in pop. and water demand. Plentiful water is obtainable from ground water stream of Rhine valley. 3 water works, one of which was taken over when formerly independent town of Durlach became part of Karlsruhe, are briefly described. Present avg. daily demand is about 50,000 cu m, with peak of 75,000 cu m. This is at present covered by 3 works, but reserves are decreasing and plans are being made for 4th works.—WPA

Water Supply Conditions in the District of North Baden with Special Reference to Water Supply and Sewage Disposal. W. KOCH. *Gas- u. Wasserfach.* (Ger.), 98:542 ('57). In N. Baden 44% of pop. live in 4 large towns, Mannheim, Heidelberg, Karlsruhe, and Pforzheim, and 83% in area which includes these towns. Chief problem of water supply is thus in W. and S. of dist. Brief acct. is given of geology and hydrology of dist. Ground water stream of Rhine valley gives sufficient water for plain country, but there are difficulties in mountainous regions. Rhine, Neckar, and Main and their tributaries are in general too pold. for use as supply but they serve to maintain the ground water resources. Water in Rhine valley is generally hard and contains manganese and iron; in sand and limestone mountain regions water is soft, but risk of poln. is greater than in Rhine valley where good filtration is insured by deep sand and gravel strata. Some old supplies from springs or shallow wells are bacteriologically unsatisfactory and require chlorination. Charts are given showing distr. of individual, central, and group water supplies, the general condition of poln. in various rivers, and quality of Neckar water from Horkheim to Feudenheim. Necessity for treatment plants for sewage and industrial wastes, especially in dist. between Karlsruhe, Mannheim, and Heidelberg, is emphasized.—WPA

(Continued on page 102 P&R)



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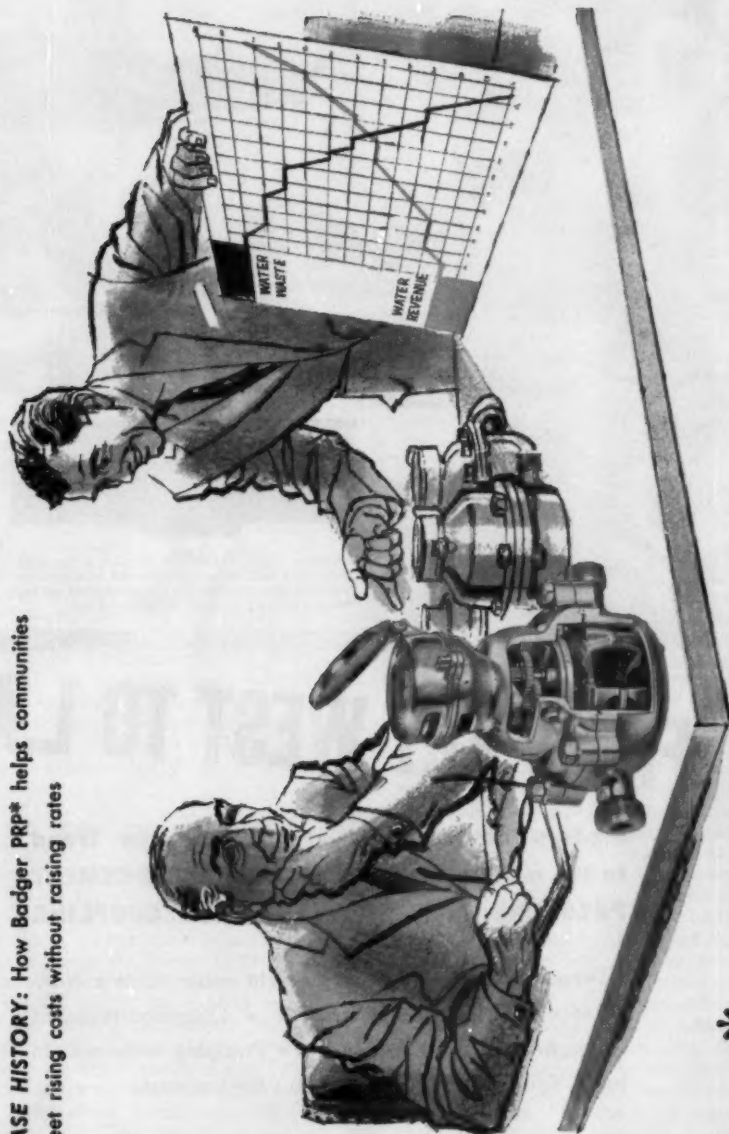
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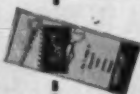
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(Continued from page 98 P&R)

Water Supply of the District Capital of Hannover. W. HOSANG. Gas- u. Wasser-fach. (Ger.), 98:387 ('57). Water supply of Hannover is drawn from 4 works using ground water. River water supply is used for street cleaning. 2 works S. of town draw water from Leine valley and 2 works N. of town draw from Luneburger Heide. Methods of collection, treatment for removal of iron, manganese, and carbon dioxide, and general design of distr. system are described. Limit of capac. of these 4 works has been reached and constr. of new works at Fuhrberg with capac. of 37,000 cum per day is planned.—WPA

The Springs of the Upper Valley of the Secchia. L. OLIVARI. Ann. chim. (Rome), 47:1359 ('57). Detailed anal. are given of water from 6 springs, all rising from sandstone and remarkably low in mineral content (residue at 180°, 0.041-0.056 g/l), pH 7.5-8.3. Principal ions found are Ca^{++} , HCO_3^- , Na^+ , Cl^- , SO_4^{--} , and SiO_2 .—CA

The Water Supply of the City of the Hague. A. J. GURCK. Aqua, 2:11 ('55). Raw water for Dune water works, The Hague, Neth., is taken from deep wells reaching into source of fresh ground water lying 165 ft below sea level; formation of this fresh-water aquifer is described. The water, which contains about 2 ppm iron and 0.25 ppm manganese, is aerated by means of spray-nozzles to convert iron and manganese into insol. compds. which are removed by rapid sand filtration, and water is oxygenated by passage through Venturi-throat into aerating tube before treatment on slow sand filters. Since aquifer is replenished by rainfall to extent equal only to about $\frac{1}{3}$ of abstractions, scheme for artificial replenishment with water drawn from R. Lek at Bergambacht has been devised. Pumping station and treatment plant are being constructed at Bergambacht where suspended solids in river water will be removed by sedimentation, and after filtration water will be carried by 28-mi long concrete main to be irrigated on to dunes near Scheveningen by means of draining galleries. To insure good qual. of recharge water it will be chlorinated at both Bergambacht and Scheveningen, if necessary. Laying of transmission main is described in detail.—PHEA



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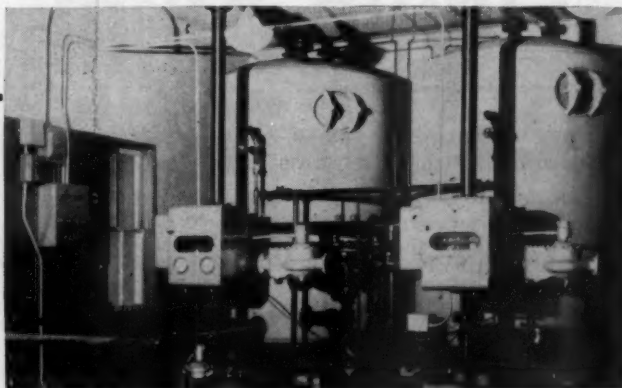
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Layne & Bowler, Inc.**Controllers, Liquid Level,**

Rate of Flow:
Bailey Meter Co.
Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Foxboro Co.
General Filter Co.
Simplex Valve & Meter Co.
Sparling Meter Co.

Copper Sheets:

American Brass Co.

Copper Sulfate:

General Chemical Div.
Tennessee Corp.

Corrosion Control:

Alco Products, Inc.
Calgon Co.
Industrial Chemicals, Inc.
Philadelphia Quartz Co.

Couplings, Flexible:

DeLaval Steam Turbine Co.
Dresser Mfg. Div.

Desalination Plants:

Maxim Silencer Co.

Diaphragms, Pump:

Dorr-Oliver Inc.

Engineers and Chemists:

(See Professional Services)

Evaporating Equipment:

Maxim Silencer Co.

Feedwater Treatment:

Allis-Chalmers Mfg. Co.
Calgon Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Industrial Chemicals, Inc.
Permutit Co.
Proportioners, Inc. (Div., B-I-F
Industries, Inc.)

Ferrie Sulfate:

Tennessee Corp.

Filter Materials:

Anthractive Equipment Corp.
Carborundum Co.
Dicalite Div.
General Filter Co.
Johns-Manville Corp.
Northern Gravel Co.
Permutit Co.
Stuart Corp.

Filters, Incl. Feedwater:

Dorr-Oliver Inc.
Graver Water Conditioning Co.
Permutit Co.
Proportioners, Inc. (Div., B-I-F
Industries, Inc.)
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filtration Plant Equipment:

Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Chain Belt Co.
Cochrane Corp.
Filtration Equipment Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F
Industries, Inc.)
Permutit Co.

Roberts Filter Mfg. Co.
Simplex Valve & Meter Co.
Stuart Corp.
Wallace & Tiernan Inc.

Fittings, Copper Pipe:

Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
Mueller Co.

Fittings, Tees, Elbs, etc.:

Alco Products, Inc.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
M & H Valve & Fittings Co.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Flocculating Equipment:

Chain Belt Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Inflico Inc.
F. B. Leopold Co.
Permutit Co.
Stuart Corp.

Fluoride Chemicals:

American Agricultural Chemical Co.
Tennessee Corp.

Fluoride Feeders:

Omega Machine Co. (Div., B-I-F
Industries, Inc.)
Proportioners, Inc. (Div., B-I-F
Industries, Inc.)
Wallace & Tiernan Co., Inc.

Furnaces:

Jos. G. Pollard Co., Inc.

Gages, Liquid Level:

Bailey Meter Co.
Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Burgess-Manning Co., Penn In-
struments Div.
Simplex Valve & Meter Co.
Sparling Meter Co.
Wallace & Tiernan Inc.

**Gages, Loss of Head, Pressure
of Vacuum, Rate of Flow,
Sand Expansion:**

Bailey Meter Co.
Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Burgess-Manning Co., Penn In-
struments Div.
Foxboro Co.
Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gasholders:

Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:

James B. Clow & Sons
Johns-Manville Corp.

Gates, Shear and Sluice:

Armco Drainage & Metal Products,
Inc.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Mueller Co.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Worthington Corp.

Glass Standards—Colorimetric

Analysis Equipment:
Klett Mfg. Co.
Wallace & Tiernan Inc.

Goosenecks (with or without

Corporation Stops):
James B. Clow & Sons
Hays Mfg. Co.
Mueller Co.

Hydrants:

James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
R. D. Wood Co.

Hydrogen Ion Equipment:

W. A. Taylor & Co.
Wallace & Tiernan Inc.

Hypochlorite; see Calcium

**Hypochlorite; Sodium Hy-
pochlorite**

Ion Exchange Materials:

Allis-Chalmers Mfg. Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.

Iron, Pig:

Woodward Iron Co.

Iron Removal Plants:

American Well Works
Chain Belt Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Jointing Materials:

Johns-Manville Corp.
Keasbey & Mattison Co.
Leadite Co., Inc.

Joints, Mechanical, Pipe:

American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:

Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:

Dorr-Oliver Inc.
General Filter Co.
Inflico Inc.
Omega Machine Co. (Div., B-I-F
Industries, Inc.)
Permutit Co.

Wallace & Tiernan Inc.

Magnetic Dipping Needles:

W. S. Darley & Co.

Meter Boxes:

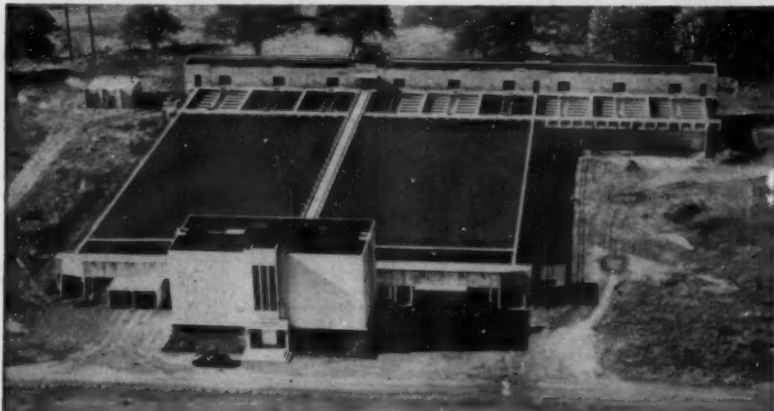
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:

Badger Meter Mfg. Co.
Dresser Mfg. Div.

7 YEARS of outstanding service!

Inertol® coatings protect Hayden Bridge Filtration Plant, Eugene, Oregon



Ramuc® Mildew-Resistant Enamel guards 250-foot-long tunnel connecting head-house with pumping section. Flanked on either side by one million gallons of cold water in twin reservoirs, the warmer tunnel is subject to heavy condensation and dripping. Tunnel is but one of many Inertol-protected areas of this plant.

Pacific Northwest's Largest Municipal Water Plant

The largest municipal water filtration plant in the Pacific Northwest, the 37.5-MGD Hayden Bridge installation serves over 60,000 persons in the fast-growing Eugene metropolitan area.

Inertol coatings, specified for this plant by Consulting Engineers Stevens & Thompson, Portland, provide attractive, cost-cutting protection . . . safeguard surfaces against condensation, mildew, abrasion, submersion and weather.

Specifications for Ramuc Mildew-Resistant Enamel

A glossy, mildew-resistant, chlorinated natural rubber-base coating, in color, for non-submerged concrete, steel and indoor wood surfaces.

Concrete Surfaces: Colors: color chart 560. No. of coats: one coat *Ramuc* Mildew-

Resistant Enamel over two coats *Ramuc* Undercoater. For flat finish, two coats *Ramuc* Mildew-Resistant Flat to bare masonry—omit undercoater. Coverage: 250 sq. ft. per gal. per coat. Approximate mil thickness per coat: 1.2. Drying Time: 24 hours. Primer: *Ramuc* Mildew-Resistant Undercoater (2 coats). Thinners: *Inertol* Thinner 2000-A for brushing; 2000 for spraying. Application: Brushing: *Ramuc* Mildew-Resistant Enamel—brush type, as furnished. Spraying: *Ramuc* Mildew-Resistant Enamel—spray type, add sufficient Thinner 2000 for proper atomization.

Buy Inertol paints direct from the manufacturer. Shipment within three days from our plant, or from nearby warehouse stocks. Write today for free "Principal Types of Protective Coatings," a short course in practical paint technology.

Ask about Rustarmor®, Inertol's new hygroscopically controlled rust-neutralizing paint.



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A COMPLETE LINE OF QUALITY COATINGS FOR SEWAGE PLANTS & WATER WORKS

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Pittsburgh Equitable Meter Div.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Gammon Meter Div., Worthington Corp.

Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Bailey Meter Co.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Foster Eng. Co.
Simplex Valve & Meter Co.
Sparling Meter Co.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Bailey Meter Co.
Buffalo Meter Co.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Gammon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co.
Well Machinery & Supply Co.

Mixing Equipment:
Chain Belt Co.
General Filter Co.
F. B. Leopold Co.

Paints:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
Alabama Pipe Co.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.
Vulcan Materials Co.

Pipe, Copper:
American Brass Co.

Pipe, Steel:
Alco Products, Inc.
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Pipe Cleaning Services:
National Water Main Cleaning Co.

Pipe Coatings and Linings:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div.
Reilly Tar & Chemical Corp.

Pipe Cutters:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate:
Carus Chemical Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
Precision Chemical Pump Corp.
Proportioners, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Peerless Pump Div.

Pumps, Diaphragm:
Dorr-Oliver Inc.
W. S. Rockwell Co.
Wallace & Tiernan Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Peerless Pump Div.
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Peerless Pump Div.

Recorders, Gas Density, CO₂, NH₃, SO₂, etc.:
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
Bailey Meter Co.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Simplex Valve & Meter Co.
Sparling Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Permutit Co.

Sodium Chloride:
International Salt Co., Inc.

Sodium Fluoride:
American Agricultural Chemical Co.

Sodium Hexametaphosphate:
Calgon Co.

Sodium Hypochlorite:
John Wiley Jones Co.
Wallace & Tiernan Inc.

Sodium Silicate:
Philadelphia Quartz Co.

Sodium Silicofluoride:
American Agricultural Chemical Co.
Tennessee Corp.

Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon Co.
General Filter Co.
Industrial Chemicals, Inc.
International Salt Co., Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.

SERVICISED SPECIAL PURPOSE PREMOLDED JOINT FILLERS

Here are three widely used special purpose joint fillers—each with specific advantages and characteristics which permit it to provide optimum performance and utility. Complete data and specifications on each type are available upon request.



Sponge Rubber CEMENTONE®

High quality blown sponge rubber, uniform in thickness and density. Neutral gray color blends well with concrete.

advantages

1. Blends with the color of concrete
2. Fully resilient
3. Non-extruding, with high recovery after compression.

recommended uses . . . For use in concrete structures where utmost resilience, non-extrusion and/or inconspicuous joints are desired. Ideal for use in tilt-up and bridge construction.

SELF-EXPANDING CORK

Similar in composition to Cork Joint, but is specially treated to enable it to expand as much as 50% beyond original thickness.

advantages

1. Fully compressible.
2. Non-extruding
3. Will keep joint spaces filled under conditions which open joint to more than original size.

recommended uses . . .

For use in canal linings and structures, outlet works, spillways, stilling basins of dams, sewage disposal plants and water filtration plants.



CORK

Composed of granulated cork and synthetic resin binder molded under heat and pressure to form a flexible, water-proof filler.

advantages

1. Light in color
2. Compresses without extrusion
3. Recovers approximately 95% of original thickness after compression.

recommended uses . . . Extensively used in flood walls, outlet works and spillways, sewage and water treatment plants, bridge construction.



Want more details on Serviced Joint Fillers? Write for new manual—"The Design and Use of Joints in Concrete Structures."



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Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
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Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
Mueller Co.

Storage Tanks; see Tanks

Strainers, Suction:

James B. Clow & Sons
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)

**Omega Machine Co. (Div., B-I-F
Industries, Inc.)**
Proportioneers, Inc. (Div., B-I-F
Industries, Inc.)
Wallace & Tiernan Inc.

Tanks, Steel:

Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
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Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
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B-I-F Industries, Inc.)

General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F
Industries, Inc.)
Wallace & Tiernan Inc.

**Turbidimetric Apparatus (For
Turbidity and Sulfate De-
terminations):**

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Turbines, Steam:

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DeLaval Steam Turbine Co.

Turbines, Water:

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DeLaval Steam Turbine Co.

Valve Boxes:

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M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.

A. P. Smith Mfg. Co.

Valves, Altitude:

Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap,

Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)

Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:

Hersey Mfg. Co.

Valves, Electrically Operated:

Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)

Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:

James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:

Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.

Rensselaer Valve Co.

W. S. Rockwell Co.

A. P. Smith Mfg. Co.

R. D. Wood Co.

**Valves, Hydraulically Oper-
ated:**

Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)

Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.

M & H Valve & Fittings Co.

Mueller Co.

Henry Pratt Co.

Rensselaer Valve Co.

W. S. Rockwell Co.

A. P. Smith Mfg. Co.

S. Morgan Smith Co.

R. D. Wood Co.

Valves, Large Diameter:

Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.

Henry Pratt Co.

Rensselaer Valve Co.

W. S. Rockwell Co.

A. P. Smith Mfg. Co.

S. Morgan Smith Co.

R. D. Wood Co.

Valves, Regulating:

DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:

Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)

Burgess-Manning Co., Penn In-
struments Div.
Simplex Valve & Meter Co.

Waterproofing:

Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div.

**Water Softening Plants; see
Softeners**

Water Supply Contractors:

Layne & Bowler, Inc.

Water Testing Apparatus:

LaMotte Chem. Products Co.
W. A. Taylor & Co.
Wallace & Tiernan Inc.

Water Treatment Plants:

American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:

Layne & Bowler, Inc.

Wrenches, Batchet:

Dresser Mfg. Div.

**Zeolite: see Ion Exchange
Materials**

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.

For The Best Connection You'll Ever Make—

ALTITE JOINT

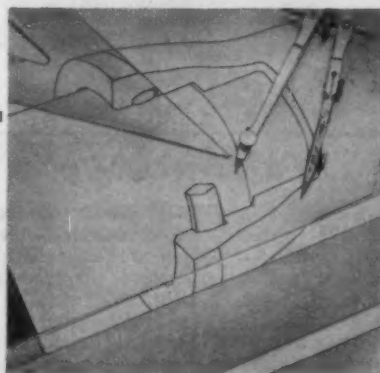
By **APCO**

Efficient, Economical and Fool Proof—



The ALTITE JOINT has been subjected to a series of rigid tests much more severe than are encountered under the most extreme installation and service conditions in the field. Even under extreme conditions, this joint is so simple to install—you could hardly go wrong if you tried.

Underwriters Approved
Patent Applied For.



For efficiency,
Economy and
Simplicity—



Order ALTITE For
Your Next Job

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General Offices — ANNISTON, ALABAMA

Four Operations
As Simple As
Falling Off a Log—



Insert Rubber gasket in
bell end of pipe — you
can't put it in wrong — A
child can do it.



Wipe on a small amount
of special lubricant—This
reduces friction.

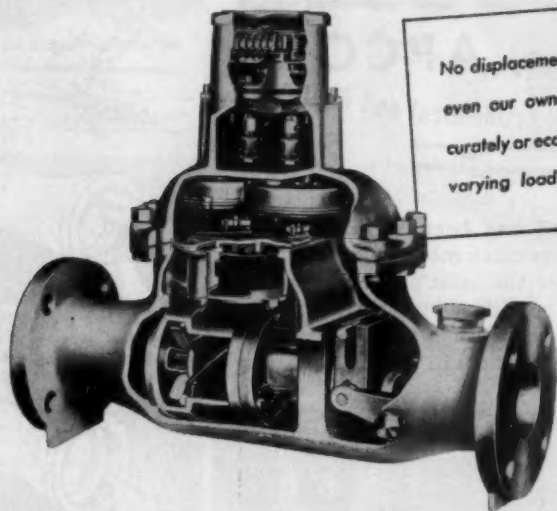


Insert plain beveled end
of pipe — there are no
grooves, ridges or tips on
gasket to interfere with
smooth insertion.



Small amount of pressure
required to force plain
end to bottom of socket—
Your simple, time saving
joint is completed.

WHY THERE IS A NEED FOR THE **ROCKWELL *Single Register* COMPOUND METER** IN 2-INCH SIZE



No displacement type meter—not even our own—can measure accurately or economically the widely varying loads of small industry.

WHEN TO USE A 2-INCH COMPOUND

When full range accuracy and maximum revenue are desired. To meet A.W.W.A. specifications, a Rockwell 2-inch compound must measure at least 95% of all water at flows of only $\frac{1}{2}$ gpm. Displacement meters need only measure 95% at 2 gpm—at rates below that accuracy falls off fast.

When continuous flow rates are in excess of 32 gpm. The propeller unit in a 2-inch Rockwell compound meter is safely rated at 54 gpm for continuous operation. Displacement type meters are rated at only 32 gpm. Thus the *continuous flow rating* for the compound is 60% greater than the positive meter.

When lower maintenance costs, fewer service interruptions are wanted. At high speeds the measuring chamber of a positive displacement meter will wear more rapidly than the propeller chamber of a compound. And since both meter units in the Rockwell compound always operate within normal capacity limits there can be no overspeeding to cause breakdowns and expensive service interruptions.

So we say if it's a job for a compound, use a compound—use the best, the Rockwell Single Register Compound meter, and save. Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania.

SINGLE REGISTER COMPOUND

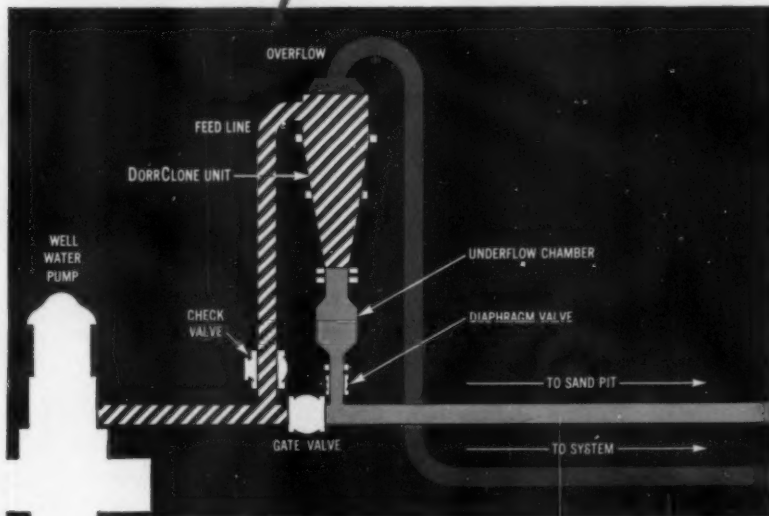
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Heart of the system is the DorrClone unit, a cylindroconical shell, shown

diagrammatically above. In operation, raw feed water enters tangentially under pressure at the top. A vortex action is created, throwing sand particles to the walls of the cone and down to the underflow at the bottom. Sand-free water at the center of the vortex flows out the top to storage, a treatment plant, or directly to the mains.

Units may be designed to suit practically all well water systems. For full information, write for a copy of Bulletin No. 2507.

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